OHIO AGRICULTURAL EXPERIMENT STATION

BULLETIN 121

WOOSTER, OHIO, SEPTEMBER, 1900

A CONDENSED HANDBOOK
OF THE
DISEASES OF CULTIVATED PLANTS IN OHIO

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BULLETIN
OF THE
Ohio Agricultural Experiment Station

NUMBER 121 SEPTEMBER, 1900

A CONDENSED HANDBOOK
OF THE
DISEASES OF CULTIVATED PLANTS IN OHIO

BY A. D. SELBY

INTRODUCTION

Before enumerating the diseases of the plants we are engaged in cultivating, it is well to consider the significance of the term "disease" as applied to plants. As used herein, the term "plant disease" means any deviation from the ordinary or average condition or behavior of a plant in respect to appearance, growth, color of bark or foliage, fruitfulness, time of dropping leaves or length of life; in short, a plant is said to be diseased when it does not conform to those averages which we have established by extended observation for the species and variety in question. In this general sense certain particolored or purple hued sports would be included, although potentially rather than actually in diminished vigor; such sports, especially the variegated types, succumb easily to parasitic attack. The more usual symptoms of disease are marked by deviations of an evident character, such as spotting, curling, discoloration or dropping of the leaves at an unusual time, the spotting and decay of fruit, or by sudden dying or blighting of twigs and branches; in all these we have apparent loss of vigor and reduced profit. Yet we must not attribute all these to fungi and insects; purely physical causes may be at the bottom of certain troubles. Plants may be asphyxiated by too much water, which excludes air supply, when they have been habituated to dry soils; they may be likewise strangled by the escape of gases, especially in the case of shade trees in cities. Furthermore, quick growing plants like cucumbers may fail in drought if started during a period of excessive rains. Plants may likewise

be injured by winter freezing, by hail, by overbearing and a variety of other causes. Some diseases are yet obscure as to cause; Peach Yellows is a type of these.

While all this needs emphasis, the larger portion of the diseases considered on the following pages are directly attributable to parasitic fungi which attack the plant in some vital part and rob it of its substance. It does not suffice to call these diseases by the old name of rust, blight, etc., irrespective of the class of fungi concerned in the parasitic attacks. The rust fungi (*Uredineae*) cause diseases properly called "rusts." So likewise the smut fungi (*Ustilagineae*) cause the well known and destructive smuts upon grasses and cereals. The anthracnoses are produced by a definite class of fungi (the *Melanconieae*). (Fig. 1). A like clearness of system in naming does not hold for all but system nevertheless prevails. To this end the common names applied have been selected in accordance with recognized usage.

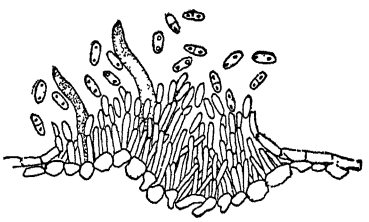

Figure 1. Section through an anthracnose spot (*acervulus*) of the cucumber anthracnose fungus (*Colletotrichum lagenarium*) showing the long dark hairs (*setae*) of whose office we know little, the spore bearing branches (*fertile hyphae*) and the spores of this fungus. The members of that division of the commoner anthracnoses having setæ in the acervuli are referred to the genus *Colletotrichum*, while similar ones without setæ bear the genus names *Gloeosporium*, *Sphaceloma*, etc. (See anthracnoses of apple, grape, lettuce, etc.)

The difference between the species of parasitic or other fungi are as strongly marked as those of higher plants, so that a discriminating system of naming diseases has a secure foundation. Further, respecting parasitic fungi, we must recognize that they are all derived by special processes of reproduction peculiar to the fungus in question; in other words, spontaneous generation does not find support among mycologists. The presence of any given fungus leads us at once to infer the previous existence, somewhere within reach, of a fungus of like species from which this was derived by definite methods of reproduction. Likewise, the destructive prevalence of a parasitic fungus in any given time and at any given place, assures us of the necessary supply of spores to start the trouble again under favorable conditions. In fact, all our study leads us to look through mere phenomena, mere evidences of disease, to find the specific parasitic growth which causes them and the favoring conditions under which these develop. The spores of fungi serve for them the same purpose as do the seeds in higher plants; by reason of the extreme smallness of the spores they are easily transported by the wind and become deposited like dust particles upon exposed surfaces. Certain resting spores survive on the fallen leaves or other parts and will be destroyed if these parts are burned.

Some fungi survive by their thread-like parts (*Mycelium*), like Canada thistle and mint among weeds by their underground stems. The bacterial diseases are propagated by minute germs, microbes, within the plants diseased, which gain entrance by the blossoms, or other openings of the plant. The water pores of cabbage plants permit the entrance of the microbes of cabbage black rot; while, in general, it may be noted that parasitic fungi of all classes may find entrance into the leaves and green stems through the stomata or breathing pores with which all these green parts are necessarily provided. (Fig. 2). All parts of higher plants which function as leaves have these stomata.

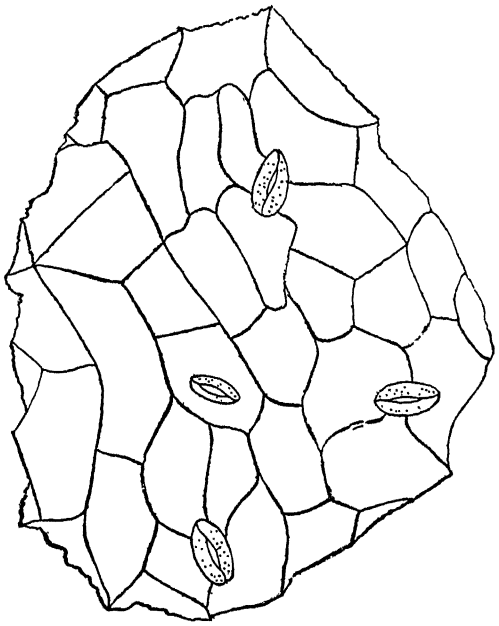

Figure 2. A portion of the epidermis from the upper surface of a cucumber leaf, showing the breathing pores (*stomata*) surrounded by guard cells containing chlorophyll grains, much magnified. These guard cells, which control the opening and closing of the stomata, are the only epidermal cells that contain this green substance, the others being colorless.

The remedies for diseases of plants are based upon the character and life history of the particular parasitic growth with which we have to deal, or in non-parasitic troubles upon the particular conditions which give rise to disease. These measures are based upon common sense reasonings derived from the known relation of cause and effect. If soil is too wet, drain it; if late growth predisposes to winter injury, avoid such growth; if overbearing weakens plants, prevent it by thinning the fruit.

In the domain of parasitic contagious diseases we have those measures which destroy the supply of spores or germs, as well as those which should avoid the conditions of danger by rotation and planting on new land. These are based on the known behavior of the parasites. In addition, we have the numerous instances of prevention by the use of fungicides; here we apply some substance which will destroy the spores already present, as in the case of grain smuts, or prevent their growth and parasitic development when deposited, as with fungous troubles generally, upon fruit and foliage. For the latter

class we have found a certain nearly insoluble copper compound, copper hydroxide, which is produced in Bordeaux mixture, to remain longer upon these parts and be still more effective than any other compounds for such purposes. The insoluble or slowly soluble character, is here a great advantage in extending the interval between applications of the fungicide.

As the ripening period of the fruit approaches more soluble compounds, which will not remain on the ripe fruit, will find application, but their effective period is shorter than for Bordeaux mixture. These measures are all preventive rather than curative. In all such matters the pathologist must work within the limitations prescribed by the behavior of the parasitic foes, and by the commercial and cultural conditions of the grower. The achievements in this line of remedies for fungous diseases have been remarkable within the past decade (See Bulletin 111 of this Station); the power of self-help given to the farmer and fruit grower by these investigations is certainly very great. These advances have made possible the summary of our knowledge of plant diseases and their remedies set forth in the following pages. It has been prepared in the hope that it may be of service to all citizens of Ohio concerned in the cultivation of plants of any class.

The illustrations in this bulletin have been largely drawn from the previous publications of this Station by Weed, Miss Detmers and the writer; small cuts have been made from certain larger illustrations while with others only a portion of the original cut has been used. Some of the illustrations are new and, unless otherwise designated, are from photographs by the writer. I beg to express my acknowledgments to Professor Halsted of New Brunswick, N. J., and Atkinson of Ithaca, N. Y., and to the Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, for recent and past favors in the matter of cuts which are used herein. In all cases it has been the aim to state the source of these cuts in the descriptions. The same applies to illustrations reproduced from standard works.

CONCERNING PARASITIC FUNGI

A fungus (plural, fungi) is a plant, a member of the class called fungi. The fungi are low in the scale of plant life, being classed with the algæ and other similar plant forms. They are lower still in the life scale than the mosses and liverworts; above the mosses come the fern-plants, and above these the seed plants, such as grasses, grains, clovers, trees, shrubs, herbs and the like, with which we come in contact every day. The fungi are distinguished from higher plants as well as from their nearer relatives, the algæ, by the absence of green color, and for that reason, we may assume, by the lack of power to prepare their own food from the mineral substances dissolved in water, and from the gases contained in the atmosphere. Herein they are marked off from most groups of plants: the fungi must live upon the substance of living or dead plants or animals. If they ever possessed the power of utilizing the same foods as most other plants, this ability has been lost. Parasitism is usually taken to indicate degeneracy in character. One way of regarding the fungi, is as algæ without chlorophyll, to which the latter owe their green color. As above stated, the fungi are, in the absence of chlorophyll, forced to live upon the dead remains of plants or animals, or to prey upon the living organisms.

CLASSES OF FUNGI

Such fungi as subsist upon living plants or animals are called parasitic fungi. A parasite is one who eats at another's table and the adjective "parasitic" comes from this word, parasite. It is the parasitic fungi especially of which we must learn, since this class produce diseases when they attack other plants. The plant attacked is the "host" plant, however unwilling the entertainment of the sycophant.

Most fungi are very minute in size and require the use of a microscope to study their parts; certain ones, however, such as the mold upon bread or other foods, may be seen very easily to consist of fine, thread-like growths interwoven together, and bearing certain rounded parts upon erect branches. Some idea of fungus-structure may be obtained by studying these common molds; that on a discarded melon rind will show the parts above described, and by the use of a microscope we may learn that the rounded, ball-like enlargements just mentioned consist chiefly of small bodies that are capable of growing into other fungus threads. (Fig. 3). Such min-

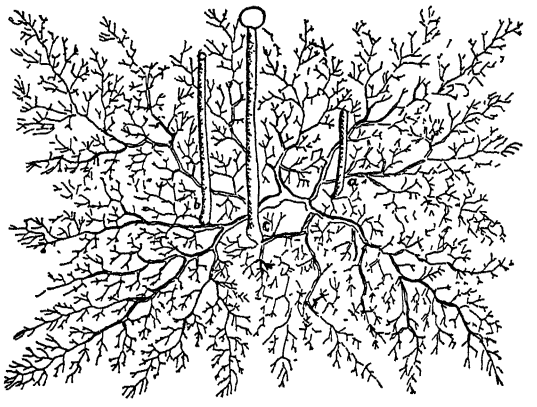

Figure 3. Mycelium of the common mold (*Mucor Mucedo*). From the spore lying near the middle of the figure, and strongly swollen, one sees the thick threads of the mycelium arise; these in turn become richly branched. There are no divisions in the mycelium. From the level of the mycelium arise three vertical, fertile hyphæ, *a*, *b*, *c*, of which *a* is still very young and that at *b* is already producing a sporangium containing many spores. All highly magnified. (After Zoph, from Reinke.)

ute parts capable of germinating and again producing the fungus are called spores. Most spores are very minute and are not heavier than the other dust particles carried by the wind. The spores of fungi are the means by which they are most commonly reproduced, somewhat after the manner that the higher plants about us are reproduced by their seeds.

While we have cited the bread mold as a good illustration to show the structure of a fungus, it is not a parasitic fungus; a mold or like growth which lives upon decaying material is called a saprophytic fungus. To this same class belong the mushrooms or toadstools that may be found in manure piles, in the woods and in orchards; the fact that we find them in such places shows that there is decaying organic substance at that point, upon which these plants may subsist. A like condition is found in the shelf-fungi on old logs and stumps, on the under surface of which we may write our names. Yet if we will use a hand lens we may often discover this under surface to be but a network filled with small openings or pores from which the spores of the fungus will in time escape. In like measure the spores of mushrooms are found in similar canals or upon the sides of the gills beneath the cap of this sort of fungus. The bacteria, or fission fungi, are one-celled plants multiplying by division and by spore production; with bacteria evident mycelium is lacking and they are structurally lower in the scale of plant life than fungi provided with a mycelium. Bacteria are both parasitic and saprophytic. But to return to parasitic fungi.

PARTICULAR FACTS ABOUT PARASITIC FUNGI

Like the bread mold, or the other fungi just mentioned, parasitic fungi consist of a growth of threads or hyphæ (singular, hypha) which do the necessary work of getting food for the parasite; these also in due time give out certain branches destined to bear spores, somewhat after the manner that the pear tree has flower clusters, or the wheat

plant forms its dense spike of bloom, both of which are especially designed to produce seeds from which wheat plant and pear tree may in turn be grown. The essential parts of a parasitic fungus are these threads, or hyphæ, and the spores produced by them. The hyphæ of the fungus taken collectively are called the mycelium, which consists of threads that produce no spores (sterile hyphæ) and of those destined for spore production (fertile hyphæ). (Figure 4). It is to the food getting qualities of the hyphæ that the fungus owes its continual existence, and they in turn arise from a spore or directly by the growth of some fragment of fungus-thread, as the Carolina poplar may be grown from a cutting. Yet, while all parasitic fungi are made up of these few parts, the differences in form and apparent structure among the several groups are very marked; differences exist as to the thickness of the hyphae whether or not the threads are divided into separate cells by divisions like those at the joints of a bamboo rod, as well as in the manner of spore formation and in the size, color, form, markings and structure of the spores themselves. It is almost hopeless to undertake to illustrate types of spore production and spore forms, since these are so varied, and may differ so much at different stages of the development of a single given species of fungus, yet we may cite a few examples:—

Figure 4. 7*a*. A portion of leaf of pea showing breathing pores and parasitized by powdery mildew; the horizontal threads (*sterile hyphae*) and summer spore bearing parts of the mildew fungus (*fertile hyphae*) are distinctly shown. In these latter the septa are evident. 7*b*. A spore sac (*ascus*) of the same fungus. 4, 5, 6, show the sucking organs (*haustoria*) of the sterile hyphæ of this fungus; these penetrate the epidermis of the leaf. 10 shows the spores of the rose mildew germinating. All highly magnified. (After Tulasne.)
NOTE—The stomate in foreground is distorted. See Fig. 2.

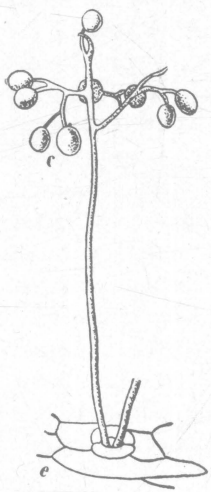

Fig. 5. Fertile hyphae (*conidiophores*) of the downy mildew fungus on *Cardamine*, a mustard, protruding from a stomate; the one shown in full, bearing spores at the ends of its branches. Highly magnified. Very similar to this are the down mildews of grape, cucumber, lettuce and some others. (After Zopf.)

Fungus spores may be produced as single spores or in naked clusters attached to certain branches. We find this sort in the downy mildew of the cucumber and its relative the peronospora of mustards (Fig. 5); in potato early blight; in fruit rot of plum, cherry, peach, etc., and later in the spores in apple scab. They may also be

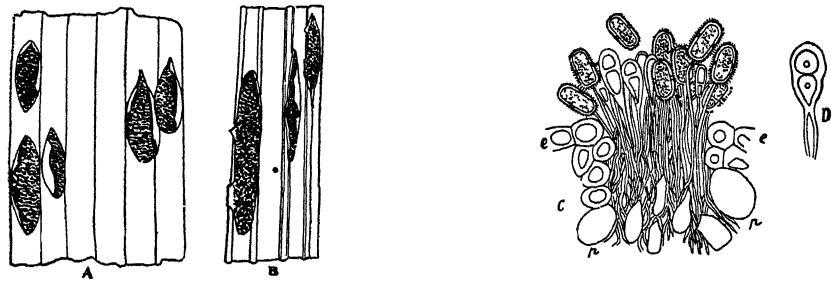

Figure 6. Showing the common rust of oats and rye. At *A* a small fragment of rye leaf with several orange-red, rust sori breaking through the epidermis; these are of the earlier summer spores (*Uredo*) or red rust of popular speech. At *B* a small fragment of a rye leaf with several black, rust sori, elongated in form, breaking through the external covering; these are of the later summer or winter spores. (*Teleutospore*). *A* and *B* slightly magnified. At *C* section through the uredo-sorus of *A*; on the slender stalks (*basidia*) the rough one-celled uredo-spores, and between them a young two-celled teleutospore, which later alone form the sorus. *e*, *e*, epidermal cells, *f*, *f*, cells of the leaf interior through which runs the mycelium of the fungus. At *D* a teleutospore from the black sorus of *B*; this is divided by a septum into two cells. Similar uredospores are found in most rusts; similar teleutospores occur in corn rust, wheat rust, etc., and in the spores of the cedar apple fungus. *C* and *D* considerably magnified. (After Zopf, from Frank.)

found in the dense clusters breaking through the skin of the plant like the many tubers of a potato breaking through the earth-crust; such, without further conspicuous covering are found in the rust spots, in the anthracnoses and the like. (Figs. 1 and 6). These dense clusters may arise beneath a special covering resembling nothing so much as the traditional beehive, but are usually ejected forcibly from a specially provided opening at the top of the cone or half-ball. (Fig. 7). A yet more interesting class is that in which the spores are packed so many to a sac (usually eight) and a large number of these crowded into a ball-like, hollow spore-case, such as we find in black-knot, strawberry leaf-spot, the powdery mildews and in some other instances. (Fig. 8). There is yet another sort in which the spore sacs are abundant near the surface of the diseased part, as in leaf-curl of the peach, where the maturity of the fungus is shown by the change in color of the affected leaf surfaces. Other gradations will be found as one proceeds in this study.

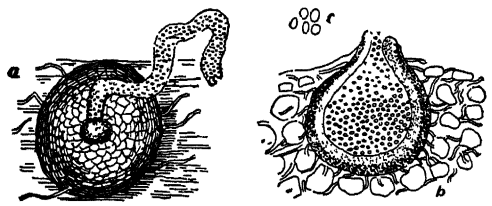

Figure 7. *a*, A spore-case (*pycnidium*) of a beet leaf-spot fungus (*Phoma*) seen from above and showing the slender, flexuous mass of spores, ejected from the pycnidium. *b*, section of pycnidium, seated in the leaf tissues and filled with spores. *c*, a groug of the spores. All highly magnified. (After Allescher and Delacroix.)

HOW THESE PARASITES ROB THE HOSTS

There is an old saying about the stable door and the stolen horse; similar application may be made for plants and parasitic fungi

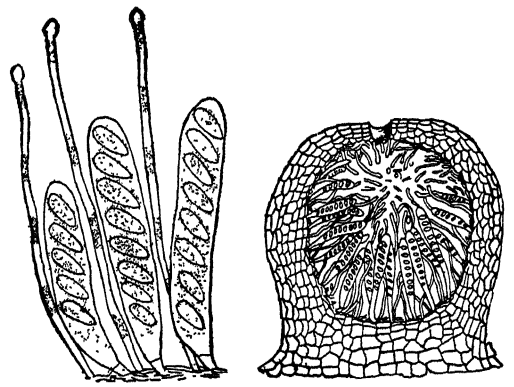

Figure 8. Section through a spore case (*perithecium*), late winter stage of black-knot fungus, showing spore sacs (*asci*) within. Beside it, three asci containing winter spores or ascospores, eight in each sac, arranged in a definite manner. Along with these are threadlike hyphæ known as paraphyses.

in a manner which we shall presently perceive. To obtain food we must reach the source of supply; the manner of reaching it is less important than the result. Now it occurs that cultivated and wild plants of the higher classes are wrapped about by a covering of skin or bark, and the food-filled juices are within; to feed upon any living host the parasite must gain access to the internal tissues of that host. It so happens that there are minute openings or stomates (breathing pores) through the skin of leaves and of young green stems; these openings are as necessary as the stable door, and through them the thief may enter. Were these openings to become entirely closed the plant would languish, and remaining open, they constantly offer a way for the slender tips of the growing germ thread of a fungus to push its way through the plant covering and to luxuriate within the host upon the substance of the plant. Once within, the fungus thrives, rapidly multiplies its branches, and if in summer, commonly thrusts its fertile threads through some of these breathing pores to bear its spores outside where they may become more widely distributed than if remaining within the tissues of the host plant. Should, however, the winter season be near, resting spores may be formed, or their formation be provided for within the leaves, or diseased parts, as in grape downy mildew, elm-leaf disease and in black-knot of plum and cherry. Thus the cycle of development continues indefinitely unless some agency intervene to destroy the spores, to prevent their germination, or the parasite itself so exhaust the host plant as to destroy it entirely and the fungus perish for lack of suitable nidus. However, this rarely occurs, not perhaps, so often as men are guilty of killing the goose which lays the golden egg. Herein, we meet another fact, namely, that parasitic fungi of a given kind are limited to a particular host plant of a certain species, or to a small number of related plants, so that if a congenial host is lacking the fungus will not thrive.

The fungus threads growing within any plant will not flourish if simply passing between the cells of the host; penetrating organs

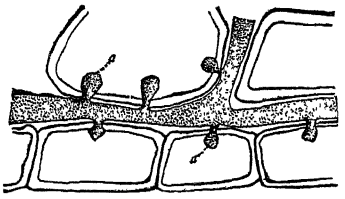

Figure 9. Haustoria of the fungus of the grape downy mildew penetrating cells of grape stem. The shaded portion shows the mycelium of the fungus growing between the cells, sending haustoria *a*, *a* into the interior of the cells. (After Scribner from Farlow.)

Note—In this figure the lower row of cells have the form of empty epidermal cells in which the fungus would find little to subsist upon. Farlow's original figure does not give these cells such form.

pierce the cell walls and are able to absorb nutriment from the cell interior. (Fig. 9). The diverse forms of sucking organs, and the peculiar structures of fungus threads in these situations would in themselves require much study and investigation to present them properly. We must further conceive that a fungus may often penetrate the bark of a tree for example, if aided by rifts caused by freezing or similar disturbances, to say nothing of the openings offered by wounds, the breaking of branches, etc. Few parasitic fungi have that penetrating power of thrusting the haustoria through the plant covering such as we find in the case of the dodder that twines about and robs the wild herbs and shrubs of the woods and fields as well as the cultivated flax and clovers.

HOW PARASITIC FUNGI AFFECT THE HOST

We know the cumulative effects of insufficient food supply; these effects must hold for plants attacked by parasitic fungi. Aside from the nutriment diverted to the parasite, there is reduced functional vigor of leaf, stem or root, and the loss becomes increased in this way. Let all the leaves be parasitized, or let even three-fourths of them be entirely so attacked, and we may look for great loss of foliage, possibly entire loss of fruit and the entailed effects of diminished vigor, unripened wood, or by repetition, entire destruction of the host. Usually the effects are of many gradations, but in all cases of leaf parasites the entire plant must suffer. We have learned that bacteria may, in a suitable medium, destroy themselves by the formation or emission of poisonous products which are fatal alike to the bacteria and to animals, or even man; that such takes place within plants parasitized by fungi remains in doubt, and may be disregarded for the present. The results of impaired function in the parts are serious enough to demand our attention. It is altogether probable that future investigations will modify our views upon some points.

There are many curious transformations and malformations resulting from the attacks of parasitic fungi. The branches of the plum and cherry become enlarged as a result of the attacks of black-knot, simply by the multiplication of cells of wound cork in the effort of the host to shut off the fungus, not because the fungus consists of such a mass of tissues. In a similar manner the leaves of the peach are thickened and "curled" by the leaf-curl fungus and the plums are made "bladders" by the fungus of plum pockets.

While exceedingly interesting to trace the effects of the white mold on shepherd's purse and on the garden purslane, as well as the effects of bramble rust, cabbage club-root and a number of others, the principle above pointed out will be found generally applicable, and it is to the reactions of the host plant that the excrescences or malformations are chiefly attributable.

It may further be stated that artificial cultures of parasitic fungi, either upon culture media or living plants are constantly adding to our knowledge in these lines.

DISEASES OF PLANTS.

ALFALFA—LUCERN.

Leaf-spot fungus:—This forage plant is grown in parts of Ohio. It is attacked by the leaf-spot fungus[1], which is found upon both leaves and stem. The small dark spots produced by it are easily seen. In attempts to produce alfalfa seed at this Station, the fungus has stripped leaves and seed capsules before maturity. It is very likely to prevent success in growing this seed in Ohio, though it is much less injurious to the forage crop proper.

APPLE.

Bitter Rot or Anthracnose[2]:—This disease is most common on Bentley Sweet and some other, chiefly sweet varieties. The fungus e ars upon the apple later than the apple scab and affects both the eating and keeping qualities of the fruit. In Virginia (Bulletins 17 and 40, Va. Exp. Sta.) spraying with fungicides is recommended. For details see spray calendar. The Bitter Rot of the Baldwin causes small sunken spots in fine fruit of this variety. It is attributed to a different fungus.[3] Orchardists who have reported to this Station upon this disease state that it is not prevented by spraying with Bordeaux mixture. At New Hampshire Experiment Station (Bulletin 45) successful prevention with this fungicide has been reported. The trees were sprayed four times, twice before and twice after blossoming. Also once before and twice after blossoming: 3 percent of the sprayed fruit was spotted with the disease while 55 percent of the unsprayed check trees were spotted. The chief gain appears to be in spraying after blossoming. A spotting of the Baldwin attributed to non-parasitic conditions is described by Stewart (N. Y. Bul. 164). Internal brown spot on Northern Spy and Fameuse or Snow apples, also on some other varieties, is at times complained of. The marketable quality of the fruit is much impaired. The exact

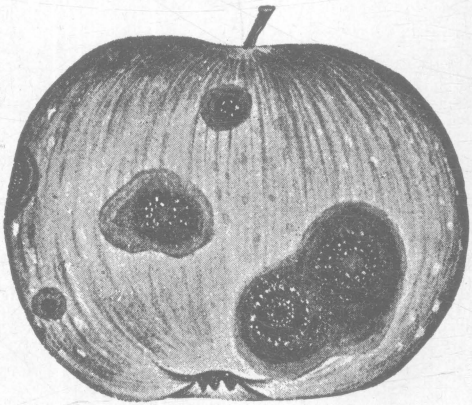

Figure 10. An apple attacked by Bitter-Rot. (After Alwood.)

[1] *Pseudopeziza medicaginis* (Lib.) Sacc.
[2] *Gloesporium fructigenum* B.
[3] *Phyllachora pomigena* (Schw.) Saac.

cause of the spotting is not known; it appears possible that it arises from impaired vigor of trees, either through lack of cultivation and pruning or from overbearing, etc.

Crown Gall:—This disease, shown in Figure 11, causes enlargements near the ground on nursery apple trees and is still somewhat obscure. It appears to be in part, at least, due to the same cause as the crown gall on raspberry and peach (which see). It is at times not easy to separate this trouble from the effects of woolly aphis upon the nursery stock. Enough appears to be known about this disease to recommend the destruction of all stock thus affected. Soil which causes this sort of growth upon peach trees in the nursery has been known to produce the same upon the apple, and conversely. Cure of diseased trees, even if attained, is likely to cost more than the value of the stock. For the nurseryman such land needs rotation in corn, clover and other crops. In all cases the crown gall stock should be burned.

Figure 11. Crown Gall of apple on nursery stock.

Sooty Fungus and Fly-speck Fungus:[4]—This unsightly fungous disease in ordinary seasons appears chiefly upon apples grown in low, moist situations. Peck's Pleasant, Rhode Island Greening, Rome Beauty and several other varieties have been noted as affected by the Sooty or Fly-speck fungus. During wet seasons, like that of 1896, a few susceptible varieties are liable to be spotted by this parasite whatever the the location of the trees. It is thought by several that the fungus spreads upon the fruit after it is stored; but at whatever time it grows the spots make the apples dull, unsightly and unsalable. Aside from selecting high, sunny situations for the apple orchard, spraying with Bordeaux mixture will prevent

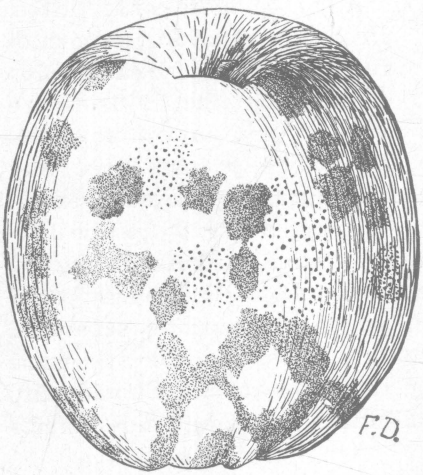

Figure 12. An apple attacked by Sooty and Fly-speck Fungus.

[4] *Leptothyrium pomi.* (Mont. & Fr.) Sacc.

this spot. One spraying may, at the time the apples are the size of hickory-nuts, prevent all or nearly all of the injury. Upon varieties like Maiden Blush, Grimes and Belmont, the spraying should be done a little earlier than just stated.

Local Blighting or Sun-scald; Canker:—This local dying of the branches and trunk of apple trees, as if blighted upon one side, is a frequent source of injury to apple orchards in northern Ohio. Upon young trees the trunks are more commonly blighted in this manner and for this trouble the term "sun-scald" is often used. The disease is not confined to any section, though more prevalent at the North. Upon many sorts the branches are locally blighted and in time that portion beyond the injured area dies. The cause of this form of "canker" is traced by Paddock (1898, also B. 163 N. Y. Ex. Sta.) to the Sphæropsis[5] fungus which attacks the fruit and leaves of the quince and the fruit of apples also. (Fig. 13). From Oregon Cordley (Bull. 60, Ore. Exp. Sta.) has described an anthracnose[6] of the apple which produces similar results on the Pacific coast to those referred above to apple canker in our region. It has sometimes been observed that this form of injury is more frequent upon the south or southwest side of the tree—trees leaning to the northeast are often injured from below. Some varieties, as the Duchess and Grimes, are said to be more susceptible. Professor Burrill (Report of the University of Illinois 1876) shows that the injuries are due, in part, to winter freezing, which prepares the way by rupturing the outer bark, but more largely to the bacterium of pear blight, which then enters and inflicts the injury stated. Winter protection of the trunks of small trees may prove useful. During the winter, injury in which the bark is separated from the trunk of apple, pear and peach trees, is often still more disastrous than the local blighting just mentioned. Should any condition, such as very warm fall rains following mid-summer

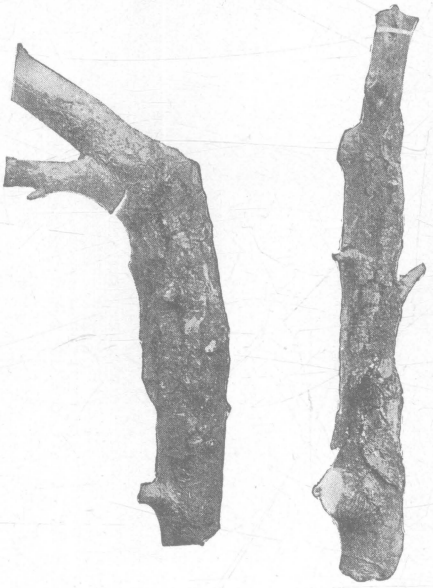

Figure 13. Apple branches attacked by Canker.

[5] *Sphaeropsis malorum* Berk.

[6] *Gloeosporium malicortis* n. sps.

drought, or late growth due to any cause, such as late cultivation, which is occasionally practiced, be followed by very severe cold in the winter, ice may form between the bark and the wood of the trunk and these so separate as to render growing together again, or healing, unlikely. Such injuries are often severe and may destroy in this manner all of particular varieties, as has occurred. Grimes's Golden, King of Tompkin's County and some other sorts, even in ordinary winters seem to die on one side of the trunk just above the surface of the ground. This injury, while not confined to any side of the trunk, is most common upon the south and southwest. In such cases winter injury may prove the cause. For protection, mulches and casings of straw seem worth trying. It is hoped that we may have observations reported upon the occurrence of toad-stool fungi about the diseased King apple trees.

Twig Blight:—This disease of the apple, caused by the bacterium of pear blight,[7] is often very prevalent. The microbe enters through the blossoms, being propagated in the nectar after infection by insect visitation. It destroys the blossoms as well as small twigs of the tree. Beyond the injuries just noted this microbe may gain entrance through the bark. (See sun-scald). The twig injury is not very great from this cause on the apple, though the small dead twigs are unsightly. The prevention will lie in the destruction of all the blighted parts on apple, crabapple, pear and quince trees in the vicinity. For fuller discussion see pear blight. In substance, this treatment consists in cutting out all blighted portions in fall and early winter and burning them to kill the resting forms of the microbe.

Root-rot:—A decay of the lower roots of apple trees is reported from Missouri. This may possibly with be us, especially in clay soils.

Scab:—Apple scab fungus[8] is a common source of large losses in Ohio apple orchards. It attacks first the leaves and afterwards the the young fruit, causing it to drop. Aside from injuring the salability of the crop obtained and reducing the vigor of the tree by reason of its attacks on the foliage, *scab may prevent a crop altogether because of this dropping of the young apples.* The Ohio Station was in the van of progress in studying this disease, and the work has been steadily followed (Bulletin 2 Ex. Sta. Bul. 121.

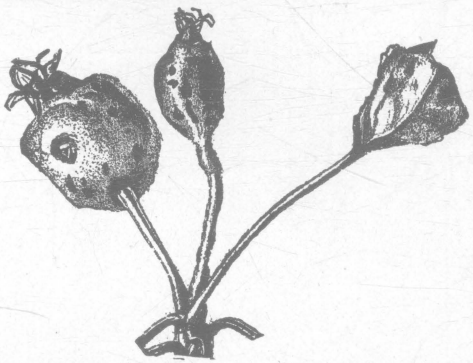

Figure 14. Young apples attacked by the Scab Fungus.

[7] *Bacillus amylovorus* (Burrill).

[8] *Fusicladium dentriticum* (Wallr). Fckl.

Vol. IV, No. 9, (1891) B. 79, (1897) B. 111, (1899).) Full details may be found in the various bulletins given. Apple scab develops when moisture is abundant during the early months of the season, and low temperatures are usually prevalent at such times. The dropping of apples often attributed to lack of pollination seems more often to be ascribed to the work of scab. All varieties are attacked but some suffer more than others.

The profits from spraying for scab on the apple (including apple worms) have generally been large because saving the amount of crop and enhancing its market value at the same time as well as increasing the number of crops. In this way the crops of a single orchard have been sold for a gain of about $1,000.00 on an expenditure of $125.00 to $150.00. At the Station this gain has amounted to $5.00 per tree (B. 111). The best fungicide for this purpose is dilute Bordeaux mixture, or Bordeaux I of the spray calendar, containing 4 pounds of sulfate of copper and 4 pounds of quicklime to 50 gallons of mixture with water. The first spraying should be made as the buds are swelling, the second just before the blossoms open, and upon the young leaves, and the third after the blossoms drop, with additions of arsenates in the third and a possible fourth spraying as stated in the spray calendar.

ASPARAGUS

Rust:—In the east and in Europe the rust of asparagus[9] proves to be destructive. and has just made its appearance at many points in Ohio. (See N. J. Exp. Sta. Report, 1896, and Bull. 129; Conn. Ex. Sta. Report, 1896, and publications of other contiguous states). The rust causes appearance of unusally early maturing of the plants. Closely examined, the rusted plants show blister-like spots on skin of the stem, and underneath these ruptures there is brown color due to the spores. The rust also assumes another form, the cluster-cup stage, which may be found in early spring with different color on volunteer plants; indeed the æcidial, or cluster-cup, uredo and teleuto-spore stages succeed each other on the stem. The usual recommendations are to burn the rusted bushes in autumn and to spray with Bordeaux mixture; this latter "reduces the amount of rust about one quarter." (N. J., B. 129). The Leopard spot of asparagus stems is apparently not

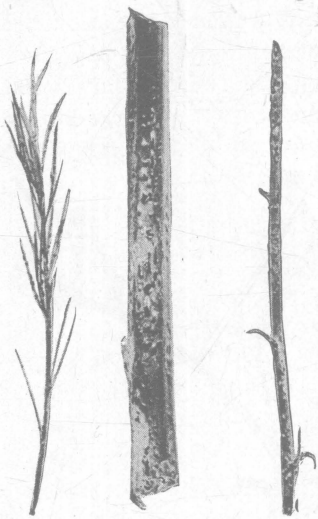

Figure 15. Asparagus attacked by Rust

[9] *Puccinia Asparagi.* DC.

infrequent, and the anthracnose of asparagus, which produces very small specks upon the stem, may also be expected, yet neither of these compares with the rust in destructiveness, nor does the rust of any other plant appear to surpass this in its ravages. The Palmetto variety is reported less susceptible to rust than any other sorts.

BARBERRY.

Rust:—The rust upon the barberry bush[10] is but a form or stage, the æcidial or cluster-cups, of the wheat rust[11]. The increase of virulence in the rust of wheat and rye, when grown near barberry bushes, was long noted before the demonstrated alterations of the fungus from the barberry to the wheat was proved in our century by De Bary. The barberry hedge is objected to, at times, by adjacent wheat growers, although we continue to suffer from the ravages of wheat rust many miles from any barberry bushes. In the absence of barberry the rust survives without it.

BARLEY

Smuts:—Two barley smuts are recorded in our district, covered barley smut[12] and naked barley smut,[13] although no considerable losses have been reported from them. In these the heads smutted by the former are stated more commonly to remain enclosed by the upper leaf sheath; a membrane likewise holds the smut masses of spores in this species, while the spores are exposed and freely scattered by the wind in the latter.

In the prevention of barley smuts it has been found (Kansas Exp. Sta. Report, 1889; Yearbook U. S. Dept. of Agric., 1894; Farmers' Bulletin, No. 75, U. S. Dept. of Agric.) that the seed barley should be soaked in cold water for four hours, set aside four hours more in wet sacks, and then treated for five minutes in hot water at 130 degrees F. and 2 degrees lower than that for wheat.

Rust:—This disease may be either an adaptive form of the ordinary grain rust, or it may be a more or less distinct species.[14] Its prevention has not yet been attained.

BEAN

Anthracnose:—The anthracnose of the bean causes unsightly spotting of both pods and growing organs and is referred to the anthracnose fungus.[15] This species is also regarded as the same one that attacks cucurbits, including cucumbers, watermelons, muskmelons and gourds. The spotting of the bean pods is looked upon, too commonly, as a natural phenomenon. Measures looking to its

[10] *Aecidium Berberidis* Gmel.

[11] *Puccinia graminis P. rubigo-vera* &c.

[12] *Ustilago Hordei* (Pers.) Kell & Swing.

[13] *Ustilago nuda* (Jens.) Kell & Swing.

[14] *Puccinia graminis* form simplex; or *Puccinia simplex.*

[15] *Colletotrichum Lagenarium* (Pass.) Hals.

prevention have not found ready applications by growers. That fungicides are effective in reducing it we may have reliable testimony (N. J. Exp. Sta. B. 108). The recommended treatment begins by soaking the seed 1 to 2 hours in ammoniacal copper carbonate, 1 ounce of copper carbonate to 1½ gallons of water. Bordeaux mixture is to be sprayed upon 2 and 3 inch plants, followed by the same 10 days later, and again repeated after blossoming of plant. (See Spray Calendar).

A Bacterial Plant has been reported from New York (N. Y. Exp. Sta. B. 181) and New Jersey (Exp. Sta. Rept. 1892) which promises more or less injury. In this malady the diseased parts, leaves, pods, etc., show characteristic, often watery spots. It is less prevalent on fresh land.

Downy Mildew:—This fungus,[16] so far as known at present, has not been found in Ohio, though occurring to a destructive extent in the east, and liable to occur in our vegetable gardens. Experiments have shown that it is controlled by spraying with Bordeaux mixture. (Conn. Exp. Sta. R. 1897, Pt. III). In this instance, as with the downy mildew of cucumber, it is probable that August 1 is sufficiently early to begin the application of the fungicides.

Powdery Mildew of the bean is due to the same fungus as the powdery mildew of pea, which see page 41.

Rust:—This fungus[17] is often observed to produce reddish brown spore masses upon both surfaces of the leaves of beans. It is perhaps rather more variable in occurrence, and certainly less injurious in the past than bean anthracnose. It has been quite common in Ohio. Beyond burning diseased refuse we are not prepared to suggest remedial or preventive measures.

BEET

Leaf-spot:—The garden beet is quite liable to the attacks of the leaf-spot fungus[18] which causes serious impairment of leaf action and premature dropping of the foliage. Other changes are likely to follow those stated. This trouble may be controlled by the use of Bordeaux mixture at fortnightly intervals. (B. 102). The leaves of beets are also attacked by a white mold,[19] although this latter fungus is less frequent and less ruinous than that of leaf-spot. The same fungicide may be used if required. (See "sugar beet" for other diseases).

BEGONIA.

Nematodes:—These minute worm-parasites attacks the roots and also the leaves of cultivated begonias (Ohio Exp. Sta. B. 73; N. J. Exp. Sta. Report 1894). For the commoner root injury avoidance is to be sought in the preparation of the earth.

[16] *Pythophthora Phaseoli* Thaxter.
[17] *Cercospora beticola* Sacc.
[18] *Uromyces appendiculatus* (P) Lév.
[19] *Cystopus Bliti* (Biv.) Lév.

BLACKBERRY

Anthracnose:—The anthracnoses of blackerry and raspberry[20] are identical and are described under the raspberry.

Leaf-spot:—This disease is also common to the blackberry, and the raspberry, although the latter is less commonly attacked. This fungus[21] is conspicuous upon the wild growth and upon the trailing dewberries; it produces, usually, small, light-gray spots in the leaves and yields to treatment with the standard fungicide. (See Ohio Exp. Sta. B. IV, 6 and B. 79).

Crown Gall:—Is apparently of a similar contagious nature to that of the raspberry. It is of like appearance, though the galls at the crown of the plant are often larger. A plant once attacked is incurable, and offshoots from it appear to be generally affected, thus calling for immediate digging and burning of all the diseased canes and the abandonment of propagation from such plantations. (See raspberry crown gall).

Red Rust or **Bramble Rust**[22] is a well known disease of the wild and cultivated blackberries, which also attacks raspberries. It causes the affected leaves to turn first yellowish in color, remain erect in position, and finally to become bright red with an abundant coating of the spores of the rust fungus. These spores are readily scattered and may thus affect previously healthy plants. The threads of the rust fungus (mycelium) live year after year in the affected plants. For this reason the only remedy is to dig and burn all members of the rusted stools. (See Bulletin 79).

BLUE GRASS

This, our best pasture grass, is an object of marked interest and solicitation. Its blades are attacked by the same **smut**[23] that is found on timothy, though destructive on neither. It causes sooty growth about the blades. This grass is also whitened at times by the conidial stage of the **wheat mildew**,[24] and is likewise susceptible to certain **rusts** that are destructive upon our grasses.

BROOM-CORN

Smuts:—Of these there are two, head smut[25] and grain smut,[26] the latter of which is prevented by treating seed for 15 minutes in hot water at 135 degrees F. and drying for planting as for oats. The same smuts attack sorghum and are very likely to occur in foreign seed. (See Kan. Exp. Sta. B. 23; Ills., B. 47).

[20] *Colletotrichum venetum* (Speg.)
[21] *Septoria Rubi* West.
[22] *Caeoma nitens* Schw.
[23] *Tilletia striaeformis* West.
[24] *Erysiphe graminis* DC.
[25] *Ustilago Reiliana* Kuhn.
[26] *Cintractia Sorghi-vulgaris* (Tul.) Clinton.

BUCKWHEAT

Leaf-blight:—This well known plant is frequently attacked by a leaf-blight fungus[27] which produces whitened areas on the under leaf surfaces and causes dying of these leaves. It is not known to be sufficiently destructive to warrant treatment for prevention.

CABBAGE—CAULIFLOWER

Brown Rot is a serious disease of these two crucifers, and attacks others of the family, including turnips. It is a veritable scourge to the cabbage growers of Ohio and other states. Smith (Farmers' Bull. 68, U. S. D. A.) has published concerning it and has attributed the disease to a specific germ.[28] The diseased heads may be dwarfed, in portions rotted, and brown colors will appear in the woody layers of the plant, including the stem. Badly diseased heads emit a penetrating and offensive odor. The losses from the brown rot have been very large and specific remedies cannot be stated. The author quoted sums up the subject of treatment in one word—prevention. The measures recommended are—plant on new land and only from healthy seed beds; avoid succession of the same crops; avoid stable manure and give preference to artificial fertilizers to escape possible infection through the manure. Prevent animals from cropping in diseased fields. Clean tools by scouring bright after use in infected soil. Fight the cabbage insects, since these inoculate healthy plants with the disease. Removal of badly affected plants, or newly infected leaves, at intervals, and subsequent burning, or deep pitting of this refuse may aid in checking brown rot. Destroy all mustard weeds.

Club-root:—Club-root fungus[29] attacks these plants as well as the turnip, ruta-baga, wild shepherd's purse, hedge-mustard and certain other plants of the mustard family. It causes enlargement of the roots and prevents growth of normal head or root. (See figure).

This fungus is harbored in the soil, so that if the land is once infected the disease may prove lasting. It has not yet been learned how long the trouble will survive if the soil is planted in other crops. Lands newly brought under cultivation may be infected with club-root through the wild mustard plants upon them. It would appear possible by watchfulness to avoid getting the club-root fungus into cabbage lands; the seed bed should be most carefully guarded from this trouble as from rot. It will be much cheaper to abandon the crop for some other, when the plant bed has become affected with club-root and the seedlings have enlarged or whitened roots from this disease.

[27] *Ramularia rufo-maculans* Pk.
[28] *Pseudomonas campestris* (Pammel).
[29] *Plasmodiophora Brassicae* Wor.

In New Jersey, Halsted has investigated this trouble and has found (N. J. Exp. Sta. B. 98 and 108) that fresh stone-lime, if applied at the rate of 75 to 80 bushels per acre upon freshly plowed land in spring, and worked into soil, will very greatly reduce the amount of club-root on turnips and cabbage; there is no reason to doubt that this treatment is applicable to all plants of the order attacked by club-root.

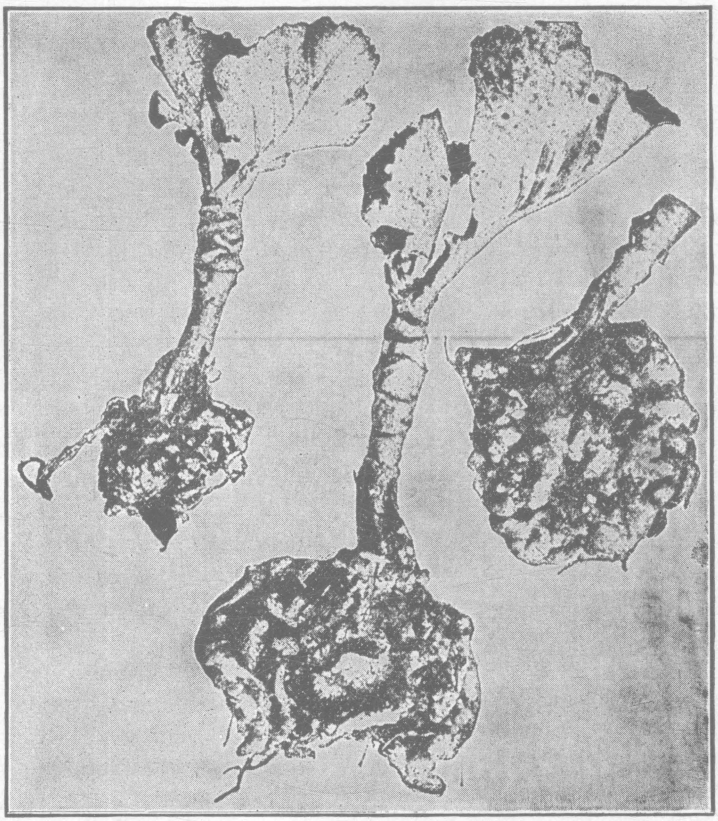

Figure 16. Young cabbages badly affected with Club-Root. (After Halsted, Bul. 98, N. J. Exp. Station.)

Downy Mildew,[30] **Leaf-Blight**[31] and **White Rust,**[32] occur upon the mustard plants, including, perhaps, all named above and some others. As yet their presence has not proved a serious drawback. If to be treated, Bordeaux mixture should be applied.

CALLA

A **Root rot** of callas is under study. The disease appears to be due to bacteria (N. J. Rept. 1893.) Reject rotted roots.

[30] *Peronospora parasitica* DeBy.
[31] *Macrosporium Brassicae* Berk.
[32] *Cystopus candidus* (P.) Lev.

CARNATION

Leaf and Calyx Mold[33] of carnations is often very unsightly upon the calyces and pedicels of these flowers; it also attacks the leaves. All sorts appear to be more or less parasitized with the fungus in the houses where it prevails. Yet another spotting is produced by the carnation leaf-spot[34] fungus, which has appeared at this Station more frequently upon the Daybreak variety. It is believed that both these fungi will yield to treatment with Bordeaux mixture as per calendar. (See Bulletin 73).

Bacteriosis of carnations has been reported upon by Arthur and Bolley (Ind. Exp. Sta. B. 59). This causes many small, brownish spots with yellowing of the leaves of the affected plants. Such are feeble in growth and deficient in return. The maintenance of best and most favorable growth conditions may often be effective in preventing this trouble; particularly sub-irrigation and war on aphides are to be recommended.

Carnation Rust:[35]—This rust fungus is one of the serious diseases of the carnation. There is some difference in the liability of varieties to the disease, and perhaps a much larger difference in the condition of the stock plants from which cuttings are made. Assuredly this matter of "cutting-stock" is of very great importance and one admitting of selection of the very best plants. Experiments conducted at this Station in 1896 by the writer and the Station Florist (See B. 73) yielded no gain from spraying with Fowler's solution, which has been sometimes recommended. Watchfulness in the destruction of rusted parts, and in the stock for propagation, are suggested for the control of rust.

A **Stem** or **Root rot**[36] of carnations has been noted by Stewart (Bot. Gaz. XXVII, 129, 130) and occasional rotting of the flowers through the presence of a Botrytis. For the former no thoroughly effective remedy is now at hand, while general cleanliness of the house is necessary to avoid the rot fungus (Botrytis). (See Lettuce rot).

CARROT

Leaf-spot:—This spotting of carrot leaves is usually caused by the same fungus[37] as the celery leaf-spot. Upon the carrot the trouble is not usually serious.

[33] *Heterosporium echinulatum* (B.) Cke.
[34] *Septoria Dianthi* Desm.
[35] *Uromyces caryophyllinus* (Schrank.) Schroet.
[36] *Rhizoctonia* and *Fusarium.*
[37] *Cercospora Apii* Fres.

CEDAR.

Cedar Apples or **Cedar Rust**:—During the showers of April, May or June, large or small, jelly-like masses, often one inch or more across, with firmer wood-like centers, are frequent upon red cedar trees and upon similar related plants. Microscopic examinations of these jelly masses show that they contain the spores of a rust fungus.[38] This fact need not startle us but for another, namely, that this is the completed or teleutospore stage of a rust which may seriously injure the leaves of the apple. The apple grower will run some risk then, in having about him diseased cedar trees. The remedy lies in the destruction of the cedar trees.

Figure 17. Red Cedar twig with Cedar Apple or Cedar Rust.

CELERY.

Black Root, so-called, may be found on celery plants from seed beds. In one instance such plants yielded growths which shortly run to seed and were valueless.

Leaf-spot or **Leaf Blight**[39] is a prevalent condition upon celery plants. This is at times attributed to the fungus above named, or others,[40] and is also produced by other causes, as by excess of water during overflow and the like. During certain seasons the loss from the leaf-spot or leaf-blight troubles is very much greater than during others. This is clearly explained when the conditions giving rise to the leaf troubles are apparent. But this by no means a common fact, and in some years there is much blighting after the celery has been boarded up for blanching. Usually the fungus is discoverable in diseased areas of the leaves. The use of fungicides, such as Bordeaux mixture, is likely to prove beneficial, especially to protect the plants in the seed bed until transplanted. (See Spray Calendar). While beneficial for later applications in the field, so long as it is not clear that the fungus parasite is not the only cause of blighting or

Figure 18. Celery attacked by Leaf-spot.

[38] *Gymnosporangium macropus Lk.* and other species of Gymnosporangium.
[39] *Cercospora Apii* Fres.
[40] *Septoria petroselina Apii;* (Desm.) Brio. & Cav.
[41] *Phyllosticta Apii* Hals.

leaf spotting, all possible conditions should receive attention. Kinney (Rhode Island Exp. Sta. B. 44) has suggested that the breaking down of celery leaves arises from the methods of culture practiced, particularly the level culture, in which the water relations of the plant are not in a natural state. He succeeded in preventing the blighting of celery by mulching with celery tops in which there was a large supply of the fungus. Mulching, especially during periods of prolonged drought, may thus prove profitable. The identification of the particular fungus occurring in the spots must, in each case, be made by the microscope. Aside from the mulching suggested the remedies are stated in Bulletin 102.

Heart Rot is a very destructive decay of the inner, or heart portions of the celery plant after blanching has begun. The inner parts rot very suddenly, emit a penetrating odor and the market value of the affected celery is destroyed. The decayed parts are teeming with motile bacteria to which this form of decay has been attributed. The heart rot prevails too in very hot, steamy weather, but preventive measures are about all that can be recommended. It is suggested that when the boards are first put up to the celery, under such conditions as accompany the heart rot, they should be left apart at the top and only closed up to the usual point after an interval of several days. This secures better ventilation and will often prevent the disease.

Rust, true and false:—In Europe the celery plant is attacked by one or two rust fungi[42] of the same class of parasitic fungi as those producing rust in wheat. These two rusts have not as yet been discovered in America, though they will doubtless in time become introduced. Celery which is banked in the earth often has the blanched stems marked by rusty spots of various sizes. These spots appear to arise from the contact of the stems with the earth, and on microscopic examination seem to be due to the fungi or bacteria, or both, that may be present in the soil. The difficulty is prevented by avoiding this method of blanching and substituting boards or close culture planting.

Bad Seed:—There is scarcely a more vital matter in celery growing than that of the quality of seed used. Seed that is of a bad strain though true to varietal name, may inflict losses of hundreds or thousands of dollars on large growers. Hollow celery, or that otherwise useless, according to present knowledge is very often due to the bad seed.

CATALPA.

Mildew and Leaf-spot:—This tree, which is often planted for ornament is sometimes rendered unsightly by the catalpa mildew

[42] *Puccinia bullata* (Pers.) and *P. Castagnei* Thüm.

fungus[43] and the leaf-spot fungus.[44] The former may be recognized by the whitish, spiderweb-like coating it produces, while numerous dead spots in the leaves will turn grayish-brown and will show the small, pin-head fruiting stage of the latter fungus. Both may be prevented by the use of the standard fungicides if application is begun with the early unfolding of the leaves.

CHERRY.

Black-Knot:—This is a conspicuous disease attacking the branches of cherry and plum trees but is more frequent upon the cherry varieties of the Morello type. It is due to a parasitic fungus.[45] Insects, however, make harbors of the interior of the knots. The spores of the black-knot fungus are ripened during the winter and scattered in early spring, finding lodgment on the new branches or in fractures upon old ones, where their growth causes the formation of a new knot. Black-knot may be prevented by spraying with Bordeaux mixture, but is more profitably controlled by carefully cutting off affected parts and burning them, making a clean sweep at least once each year and that *previous to March 1st.* This is a practicable measure and we have confidence in its efficiency.

Figure 19. Cherry twig attacked by Black-Knot.

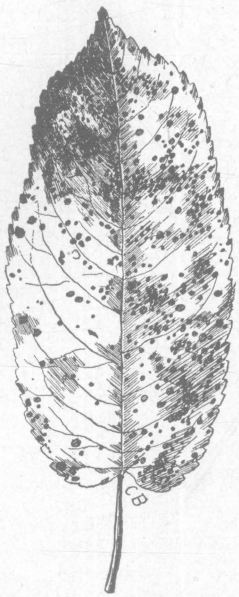

Figure 20. Cherry Leaf-spot.

Leaf-spot and Mildew:—The first named disease is caused by the same fungus[46] as that which we call "shot-hole fungus" on the plum, and may be successfully prevented by the use of Bordeaux mixture, except that only half the strength of mixture may be applied with safety to the foliage of the cherry. (See calendar). The mildew is usually found chiefly upon sprouts and young shoots. The mildew fungus[47] is a very interesting one. This applies especially to amateur microscopic study. If spraying is required for the mildew two applications will probably be very satisfactory.

Cherry Rot or **Brown Rot,**[48] affects all stone fruits, including peach, plum, apricot, etc. It is by far the most baffling of cherry diseases to

[43] *Microsphaera elevata* Bur.
[44] *Phyllosticta Catalpae* Ell. & Mart.
[45] *Plowrightia morbosa* Schw.
[46] *Cylindrosporium Padi* Karst.
[47] *Spaerotheca Oxyacanthae* (DC.) De By.
[48] *Monilia fructigena* Pers.

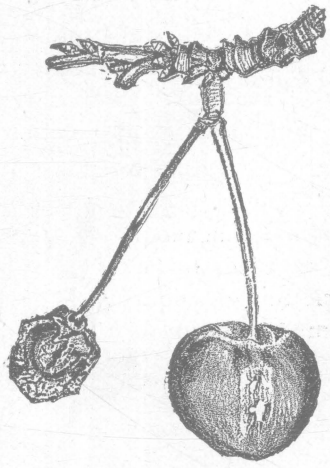

Figure 21. Rotted and sound cherries.

the commercial cherry grower. The decay of the fruit is caused by the fungus named. The conditions of the season may favor or retard the spread and development of the fungus. The threads of the fungus (mycelium) survive in the rotted fruits, which may hang on the trees unless removed. Careful removal of all rotted fruit and spraying for the fungus, as per the calendar may be relied upon to save a part of the fruit, but judgment and attention to the details of the work are always required. It is to be understood, also, that checking the curculio is a mere means of helping to check rot.

CHESTNUT.

Anthracnose is a disfiguring spotting of chestnut leaves, about which inquiries are often made. Small, dead areas with characteristic borders are produced by this fungus.[49] Such applications of fungicides as are made for shot-hole fungus of the plum and leaf-spot of the horse chestnut, will be found useful when treatment becomes necessary on the chestnut.

CHRYSANTHEMUM.

Leaf-spot is frequently a disfiguring disease of this plant in earlier growth. It is caused by the leaf-spot fungus.[50] Two other fungi, a Phyllosticta and a Cylindrosporium, also attack the chrysanthemum. For indoor treatment copper sulfate solution of one-fourth of the strength given in the spray calendar—that is one pound to 50 gallons of water—will prove available. More applications will be required, but the foliage will not be rendered so unsightly as with Bordeaux mixture which, however, may be applied in full strength.

Rust:—This is found on the chrysanthemum, resembling other rusts in its development. Rusted leaves and badly rusted plants should be destroyed.

CLOVER.

Dodder:—Clover dodder[51] is a parasitic seed plant increasing in frequency. It destroys patches of clover or alfalfa where present. (See Weed Seed Illustrations and Bulletin 83).

Rust:—The various sorts of the cultivated clover, Red, Alsike, Mammoth, etc., are attacked by a clover rust.[52] If one will examine

[49] *Marsonia ochroleuca* B. & C.
[50] *Septoria Chrysanthemi* Cav.
[51] *Cuscuta Epthymum* Mürr.
[52] *Uromyces Trifolii* (A. & S.) Wirt.

the small, dark spots in the clover leaves he will find a cluster of this reddish fungus beneath. This rust does not spread to other plants than clovers and is commonly regarded as more disfiguring than destructive. It is not nearly so injurious as the leaf-spot of alfalfa which is similar in appearance.

Root Nodules and **Root Tubercles upon Leguminosae:**—Upon removal of the roots of the clover plant from the soil one finds minute enlargements which are the subject of frequent injury. These are nodules or tubercles as they were formerly called, caused by the messmate-living of certain nitrifying organisms, or microbes, with the clover plant. To these microbes in this communal life is due the power of withdrawing nitrogen from the atmosphere and fixing it in the tissues of the clover plants. The same applies in general to the nodules upon plants of this order, the *Papilionaceae*. It thus follows that these nodules are the normal condition of properly nourished leguminous plants of the order *Papilionaceae*, and it likewise follows that the full value of this work of nitrogen fixing is only realized for manurial purposes when the tissues of the clover plants decay in the soil.

CORN.

Bacterial Disease:—This has been described and illustrated in Bulletin 6 of the Illinois Experiment Station, 1889. The malady infests both younger and older plants. In the younger it causes a yellowish coloring and a general appearance of debility, with death of the leaves, commonly from the joint backward. After midsummer, spots appear on the exterior of the sheaths which are more conspicuous on the inner side and at times more or less smeared with a gelatinous substance. No successful remedy has as yet been proposed.

The Leaf Blight Fungus[53] has been noted in corn and has recently been sent to this Station from Vinton county, in the latter case upon sweet corn. The fungus causes somewhat extended, or elliptical brown (dead) areas in the leaf blades, readily identified by the microscope. All diseases of the young corn attract notice, but it is not certain that there is need to apply fungicides for this fungus, though such might prove successful.

Corn Rust[54] is met with in greater or less abundance upon corn every season, the greater abundance usually being in rainy seasons. The rust causes small oblong or elliptical spots on the surface of leaf and sheath and in the spots are contained reddish-brown spores of the rust. The shades of the spores will vary with the time and development of the fungus. Here, as with wheat, the fungus passes through the uredo and teleuto stages.

[53] *Helminthosporium graminum* Rab. [54] *Puccinia Maydis* Berang.

Corn Smut is a well known disease, attacking leaves, shoots, ears, tassels, and brace-roots of corn, converting the diseased parts into masses of dirty (smutty) spores of the fungus.[55] A brief article upon corn smut will be found in Bulletin 78. (See also Bul. 92 of the Kansas Experiment Station.) The corn smut may be propagated by smutty seed, although much more likely to be carried by the transportation of the yeast spores of this smut fungus which may alight upon any young, growing part and produce smut infection. From this reason and from another—probably a greater prevalence of the smut yeast spores in later summer—later growing parts, for example, tassels, brace-roots, ears and sucker shoots, are perhaps more often attacked by the smut. The smut spores may be scattered in manure if smutted fodder is used, and it seems well proved that manured land yields more smutted corn than unmanured. The same may be true of clover sod as compared with corn stubble. The reason would exist in the decayed vegetable matter, wherein the secondary yeast spores of the smut may grow and then may be carried to the corn which becomes thus affected. Treatment of seed corn does not apparently reduce the amount of smut. Cutting and burning the smut boils before they have burst open would prove useful. It is worth while to fight smut by all available means.

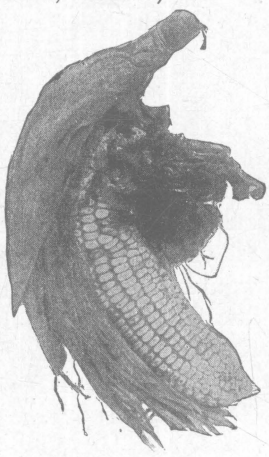

Figure 22. Ear of corn partly smutted.

CRAB-APPLE.

Scab:—The same scab which attacks the common cultivated sorts also attacks the crab-apple, including both fruit and foliage. The remedy is that given under apple.

CUCUMBER.

Anthracnose:[56]—This fungous disease attacks nearly or quite all cucurbits as well as the bean. Upon the cucumber in Ohio it is apparently more destructive during the earlier season. The fungus may be found in the greenhouse at all cultural periods, as well as in the field. It causes circular dead spots in the leaves, usually more than one-fourth inch in diameter, and likewise elongated brown areas on the stem. (See Bulletin 73, 89 and 105). Unlike the downy

[55] *Ustilago Zeae* (Beckman) Unger.

[56] *Colletothrichum Lagenarium* (Pass.) Hals.

mildew, anthracnose may be checked after it appears, though best prevented by earlier applications of the fungicide. In the field, Bordeaux mixture is to be preferred; in the greenhouse, copper sulfate solution, one pound to 50 gallons, has proved efficient and has checked the anthracnose after one-fourth of the plants had been destroyed by it.

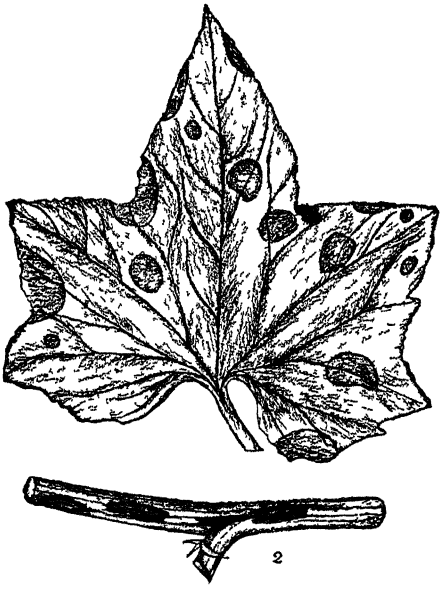

Figure 23. Cucumber leaf and stem attacked by anthracnose.

Downy Mildew:—Downy mildew fungus[57] is late in its attacks, not having been found in Ohio fields earlier than August 3rd. It causes angular, yellowish spots in the leaves, followed by yellowing of the whole leaf and death, as by frost. It spreads with extraordinary rapidity, requiring only three or four days to become disseminated throughout a large field. Unlike anthracnose, it may not be successfully checked after its appearance, and it is not safe to leave untreated plots in the field to be sprayed. July 25th to August 1st is sufficiently early to begin spraying for mildew, but applications should be repeated at intervals of 7 to 9 days. In 1898 an increase of 75 bushels per acre, of sprayed over unsprayed cucumbers, was obtained at Creston. (Bulletin 105). Cucumber pickle growing finds in this mildew its most serious enemy. If any of the crop is to be harvested after August 20-25 spraying with fungicides appears necessary. Early planting may permit gathering the crop before this date. The downy mildew is also very destructive in the

Figure 24. Cucumber leaf with Downy Mildew. Lighter areas are yellow in leaf.

[57] *Plasmopara Cubensis* (B. & C.) Humph.

forcing house, and is to be treated with the same fungicides recommended for anthracnose. (Bulletins 73, 89 and 105).

Powdery Mildew[58] of cucumbers is also frequent in the forcing-house, but rarely destructive elsewhere. For this fungus a dilute copper sulfate solution is effective. (See Bulletin 73.)

Leaf-spot of cucumber is also due to fungi.[59] Of the two species named, the Phyllosticta was the commoner in thrifty pickle fields in 1898; the Cercospora being apparently confined to wet fields, though this cannot be expected to hold true under all circumstances. The Phyllosticta was found almost exclusively upon the unsprayed pickle plants and seems, therefore, amenable to the same treatment as applied for downy mildew. (Bulletin 105).

Spot of Cucumber Fruit or **Cucumber Scab**,[60] has been reported upon cucumbers by Dr. Arthur, (Ind. Exp. Sta. B. 19) and may prove injurious if prevalent. It should be found amenable to the same treatment recommended for anthracnose and downy mildew.

Cucumber Wilt:—The wilt disease of cucumbers, likewise of other cucurbits, is a source of usual complaint in the earlier season, as the plants are beginning to form vines. In 1899 these complaints continued much later. These plants suddenly wilt down as from lack of water, then soon die. What has been referred to the same general cause was also observed in the cucumber forcing-house, apparently starting in the leaves. Smith (Proc. Am. Ass. Adv. Sci. 1893) refers this disease to a bacterium[61] which is transferred from diseased to healthy plants by the cucumber beetle and the squash bug. This form of wilt has been found on cucumbers, muskmelons and squashes in Ohio. In addition we have found, to a limited extent, another wilt disease of the cucumber which appears to be similar to that described by Dr. Smith. (Proc. A. Ass. Ad. Sci. 1895, page 190). On watermelon in the South he finds a trouble with which ours may be identical. (Bulletin 105, page 222). This latter is referable to a species of fungus, a fusarium,[62] which grows internally in the stem and finally plugs up the water vessels in a manner similar to the work of the bacterial wilt. Spraying is unlikely to be beneficial for this wilt or for the bacterial one. Preventive measures suggest gathering and burning infected vines, and especially waging a successful war against the insects; these should prove more or less successful according to thoroughness secured. The last named wilt disease will call for rotation of crops.

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[58] *Erysiphe Cichoracearum* D. C.

[59] *Phyllosticta Cucurbitacearum* Sacc. and *Cercospora Cucurbitae* E. & E.

[60] *Cladosporium cucumerium* Ell. & Arth.

[61] *Bacillus tracheiphilus* Smith.

[62] *Fusarium niveum* Smith.

mixture of potassium sulfid. In at least one instance the mildew spread from the Industry foliage to a large area of young currants.

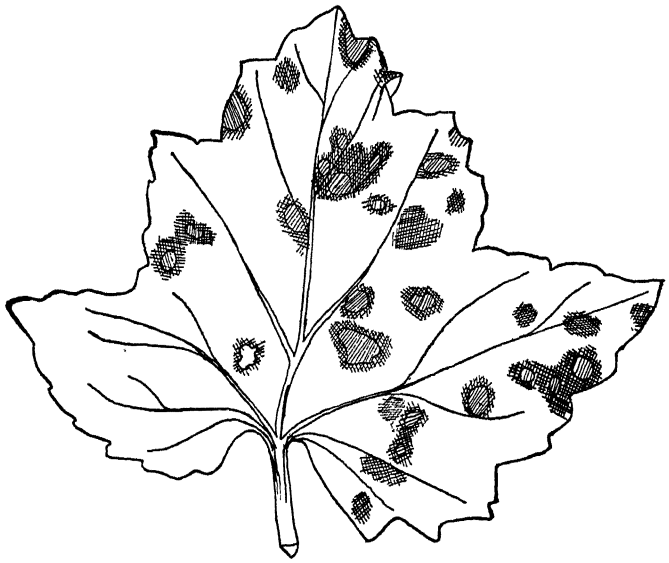


Figure 26. Leaf-spot disease of Currant.

DEWBERRY.

Leaf-spot:[65]—Cultivated dewberries as well as the wild sorts, are peculiarly susceptible to the attacks of the leaf-spot fungus. It causes very small grayish spots in the leaves. The same fungus attacks blackberries and raspberries, as previously stated. It may be prevented by a careful application of Bordeaux mixture.

Rust:—The bramble rust also attacks the dewberry as in the case of blackberry. For treatment see blackberry.

EGG-PLANT.

Dr. Halsted and Dr. Smith have reported (Rep. N. J. Exp. Sta. 1890-91-92; Bulletin 12, Div. Veg. Phys. and Path. U. S. Dept. Agr.) several diseases upon egg-plant, including anthracnose, bacterial blight, leaf-spot, seedling rot and stem rot. These do not seem to require extended discussion in this place.

ELM.

Leaf Disease and Mildew:[66]—The leaves of ornamental elm are sometimes attacked by a fungus which produces small, circular dead spots. This fungus matures its spores in the fallen leaves and may be somewhat checked by gathering and burning them. Elm

[65] *Septoria rubi* West.

[66] *Gnomonia Ulmea* Thüm.

Nematodes or Eelworms:[63]—These minute parasitic worms are often very destructive upon cucumbers under glass. They are especially so in some cases recorded in Bulletin 73. The greatest injury may occur on the seedling plants, but plants of all ages are destroyed by the parasitic worms. Their presence may be known by the small, bead-like enlargements produced upon the roots or rootlets. This matter is treated at some length in that Bulletin. No remedy has been discovered that is effective with plants once attacked by eelworms. The time to prevent this trouble is in the selection and preparation or treatment of the soil for greenhouse benches. Indeed the nematodes seem to be present in old sod, and to some extent in decaying vegetable matter generally. An effective remedy against eelworms consists in steaming and so treating the soil that the parasites will be destroyed. For this procedure see calendar and Bulletin 73. Also Massachusetts Exp. Sta. Bul. 55. In thus handling the soil due time must be given for draining and drying.

Figure 25. Roots of seedling cucumber with Nematode Galls.

CURRANT.

Dropsy:—This disease has been met with. It causes very considerable enlargement upon the young stems of the currants, not unlike in appearance the enlargements due to crown gall in the peach, except that usually more of the stem is involved than in the other case. The trouble appears to be due to physiological causes and the pruning knife may aid cultural efforts.

Leaf-spot of currants is referable to two species of fungi,[64] of which only the Septoria has been discovered in Ohio. (See Bulletin 79). These fungi produce early spotting and premature dropping of the currant foliage; in some instances the leaves drop even before the fruit has ripened. Bordeaux mixture applied as per calendar is effective against this disease, though late applications may render it necessary to wash the fruit. For this reason, if for no other, the first applictaion should be made very early and followed by about two more at fortnightly intervals.

Mildew:—This trouble is identical with the mildew of the gooseberry, which is successfully prevented by spraying with Bordeaux

[63] *Heterodera radicicola* (Greef.) Mull.

[64] *Septoria ribis* Desm., *Cercospora angutata* Wint.

leaves are also attacked by the powdery mildew.[67] This, if disfiguring, may possibly be reached by Bordeaux mixture, making the first application when the leaves are about half grown.

FLAX.

Dodder:—Flax is attacked at times by a seedling parasite, flax-dodder,[68] whose tiny, leafless stems wind about the flax plant and by haustoria, or sucking organs penetrating the epidermis, draw from it substances essential to healthy growth. The dodder seeds are carried in the flax seed and prevention must seek to avoid the seeds.

GOOSEBERRY.

Leaf-spot:—The gooseberry leaves are attacked by the same leaf-spot fungus recorded upon the currant,[69] although the defoliation may be even more severe than on the currant. In spraying experiments at this Station, conducted by the Horticulturist, it has been found that the gooseberry leaf-spot is even more easily prevented than the currant leaf-spot. Indeed no fungous disease upon which we have experimented is more easily prevented when the fungicide is applied at the proper time. (See Spray Calendar). Often the leaves from gooseberry plants have all dropped before maturity of fruit, and in hot weather all the fruit has been lost on the unsprayed, check plants, while the sprayed plants gave a fine yield of satisfactory fruit.

Mildew[70] is a destructive fungous disease especially common upon English varieties, such as Industry, Crown Bob, etc. It has been destructive also upon the Houghton. As already stated this mildew attacks currants. From the nature of this fungus the first spraying with Bordeaux mixture should be made early in the season. (See Bulletin 79). Subsequent applications may be either of Bordeaux mixture or potassium sulfid. (See calendar). After fruit is half grown the latter fungicide is to be preferred since it is more easily removed from the fruit.

GOURD.

Anthracnose, Downy Mildew, etc.:—Gourds are susceptible to the same fungous diseases as the cucumber. The two most conspicuous are anthracnose and downy mildew. The anthracnose, especially, causes spotting and discoloration on the gourds. This may be arrested if, when the gourds are gathered, they are subjected to treatment with scalding water; otherwise the development of the fungus continues while the disfiguring increases. Field treatment in this case is the same as recommended for like diseases of the cucumber.

[67] *Uncinula macrospora* Pk.
[68] *Cuscuta Epilinum* Weihe.
[69] *Septoria ribis* Desm.
[70] *Sphaerotheca mors-uvae* (Schw.) B. & C.

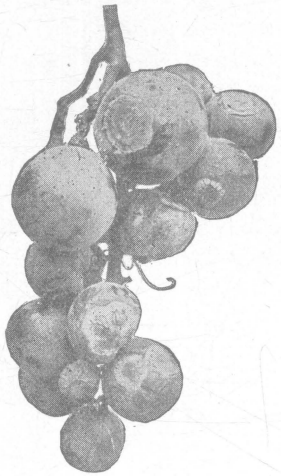


Figure 27. Grapes attacked by Anthracnose, also called Birds-Eye Rot.

GRAPE.

Anthracnose:—As is well known we have a long list of fungi attacking the grape, among them the anthracnose fungus[71] which is found upon leaves and stems as well as the fruit, causing definite sunken spots, usually with a central area of lighter color. Upon the fruit the appearance has suggested the name "bird's-eye-rot." Where prevalent the anthracnose may be entirely prevented by following the directions in the use of Bordeaux mixture as given in the calendar.

Bitter Rot[72] of the grape is sometimes prevalent but perhaps less frequent in Ohio than the black rot.

Black Rot[73] is one of the most troublesome and destructive of grape diseases. It

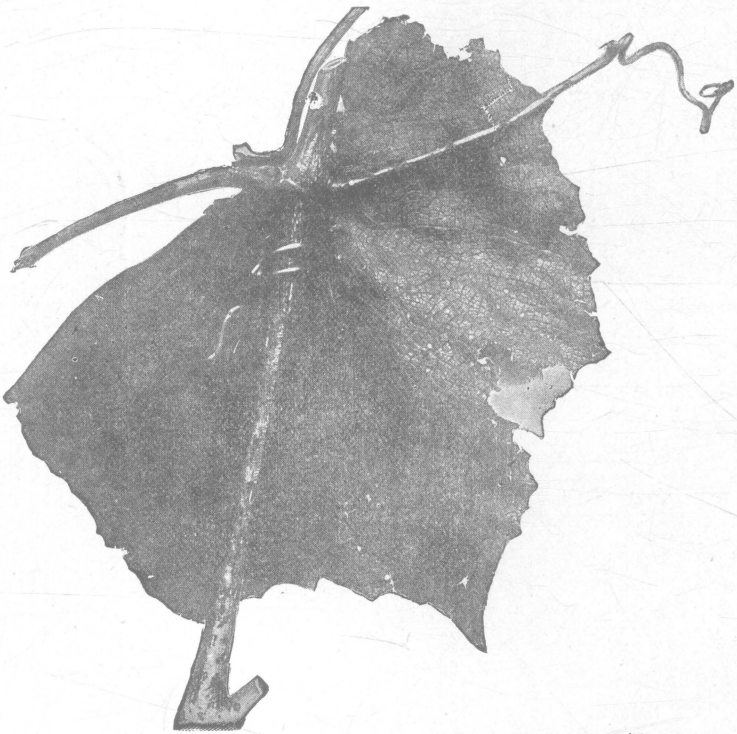


Figure 28. Leaf and stem of grape attacked by Black Rot fungus. (From photograph by J. F. Hicks and P. A. Hinman).

[71] *Spaceloma ampelinum* D'By.

[72] *Melanconium fuligineum* (Scrib. & Viala.) Cav.

[73] *Laestadia Bidwellii* (Ell.) Viala & Ravaz.

chiefly attacks the fruit and causes dark spotting and rotting of the green berries, but it may also attack the leaves, petioles and cluster branches, producing circular or elongated dead spots in them. The rotted fruits persist upon the branches and may hang on over winter, thus carrying the fungus from year to year. This disease, if neglected, is very destructive and the longer the neglect the greater is the difficulty in prevention. Because of the circumstances stated, delay in beginning the treatment increases the difficulty. It is apparently essential that first applications of fungicide for the black rot be made while the vines are dormant and that these be very thorough, followed by the later applications as per calendar. Omission of the spraying just before the blossoms open may lead to ragged clusters, from dropping of small grapes. (See Report of the U. S. Dept. of Agr. 1896.)

White Rot,[74] or a disease thought to be this, prevails now in northeastern Ohio vineyards. It has been very destructive in portions of Ashtabula, Lake, Cuyahoga and Lorain counties for the past three seasons, being usually associated with black rot. It is characterized by late development, more especially in later July and during August. First a light colored spot, then the whole grape hangs rotted and of the same light brown color, with fungus pustules of darker brown, subsequently mealy white in the dried grape. The period when the grapes begin to assume a ripened color is one of great danger. It seems that this same rot prevailed in 1872 and was locally called "Greeley Rot." The treatment is about that for black rot with perhaps more emphasis on the later applications of Bordeaux mixture and ammoniacal copper carbonate.

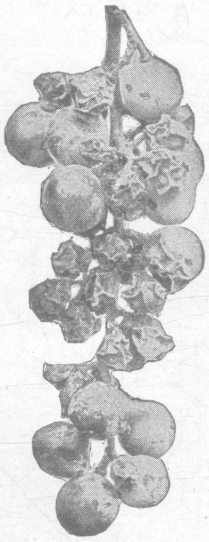


Figure 29. A cluster of grapes attacked by White Rot.

Downy Mildew[75] of the grape is a prevalent fungus disease which has long been known and repeatedly studied. By it the leaves are attacked and the fungus forms in them öospores by which the winter is passed. The fungus also attacks the berries, causing brown rot. Gathering and burning the fallen leaves may therefore be useful. No particular difficulty attends the prevention of downy mildew if spraying is thoroughly done.

Powdery Mildew[76] is likewise prevalent upon both leaves and fruit. Like all powdery mildews the parts attacked are covered over

[74] *Coniothyrium Diplodiella* (Speg.) Sacc.

[75] *Plasmopara victicola* (B. & C.) Ber. & D'Ton. [76] *Uncinula necator* Schw.

by the web-like threads of the mildew fungus. This is successfully prevented by the use of Bordeaux mixture as elsewhere directed. (For illustrations of grape diseases see Report U. S. Dept. of Agriculture 1886 and 1887; also Scribner, "Fungus Diseases of the Grape, etc."

Grape Canker or Winter Injury has been frequently referred to us. Owing to the injury caused by freezing, dead spots are produced in the vine, which in the process of healing become surrounded by excessive growth and enlargement. In some instances the enlargements attain a diameter two or three times that of the stem. Care in the matter of drainage and judicious pruning seem to be useful against this trouble.

Crown Gall of the grape, in which considerable enlargements are formed near the surface of the crown similar to the excrescences upon fruit trees, is a common trouble of the Pacific slope and doubtless occurs in Ohio. Removing and burning the affected vines is recommended.

GRASSES.

Smut and Rust are found upon most species of grasses. These are in part described under blue-grass, timothy, etc.

HOLLYHOCK.

Anthracnose:[77]—An illustration has been published in the Journal of Mycology (Vol. 6, 46-48).

Leaf Blight[78] is another fungous disease of the hollyhock. These two diseases of the hollyhock should be amenable to spraying with standard fungicides.

Rust:[79]—On the other hand this recently introduced disease of the hollyhock is much less likely to be prevented by spraying. The rust fungus forms dense patches, spots or sori, on the under side of the leaves. These are commonly about one-sixteenth inch in diameter or more, of grayish-brown color and projecting below the leaf surface, while a minute yellow spot early appears on the upper surface of the leaf. Subsequently the diseased leaves drop and by the time the plants are blooming the stem below is bare or disfigured by the remains of the diseased leaves. At the Station this rust has been prevalent and the complaint is general respecting the same trouble. It would seem wise to gather and burn all the affected leaves and likewise the old stems as early as possible. Between anthracnose and rust these popular old flowers are having, at present, a difficult time of it.

[77] *Colletrichum malvarum* (Braun. & Casp.) Southw.
[78] *Cercospora Althaeina* Sacc. [79] *Puccinia Malvacearum* Mont.

HORSE-CHESTNUT.

Leaf-spot:[80]—This popular shade tree is attacked by the leaf-spot fungus which causes spotting and dying of the leaves, with subsequent dropping from the tree. This seriously disfigures the tree and must impair its vigor. The disease may be checked, or altogether prevented by the proper use of Bordeaux mixture. Results of experiments are reported in the Journal of Mycology (Vol. VII, page 53). The first application should be made when the leaves are about half grown, with repetition at intervals of about three weeks.

HORSERADISH.

Leaf Blight and Leaf-spot Fungi, Ramularia and Septoria respectively, sometimes attack the leaves of horseradish. The same is true of **white mold**[81] which is so generally prevalent on mustard weeds. The injuries are not usually important and certainly, in no case observed by the writer, has there been any serious check to the horseradish when growing as a weed.

LETTUCE.

Anthracnose or Leaf Perforation:[82]—This disease of greenhouse lettuce was described in Bulletin 73. It has since been reported in some other localities. In well regulated greenhouses the disease is unlikely to prove serious, although disfiguring.

Downy Mildew[83] is the work of another fungus which belongs to the same class as the downy mildew of the cucumber. It forms yellow spots in the upper leaf surface which appear below as whitened, downy covered areas. Like the downy mildew of cucumbers this one may spread very rapidly under favorable conditions, such as warmth and surface watering in the greenhouse. Keeping water from the foliage by sub-irrigation of the beds has been found very beneficial (Bulletin 73). Gathering and burning the diseased leaves or plants will usually repay the labor. Particular attention to heat and moisture will usually render spraying unnecessary and it is certainly inadvisable except to eliminate the fungus from the house. Avoid too high temperature or too much moisture on plants.

Lettuce Rot or Lettuce Drop:—This is by all odds the most troublesome disease to the lettuce grower. The plants may rot off at the surface of the earth and the central parts, especially of head lettuce, may become attacked by the rot fungus.[84] The fungus

[80] *Phyllosticta spaeropsoidea* E. & E.
[81] *Cystopus candidus* (P.) Lév.
[82] *Marsonia perforans* E. & E.
[83] *Bremia Lactucae* Regel.
[84] *Botrytis vulgaris* Fr.

appears as a whitened covering with a liberal production of spores in clusters. At this Station it has not been possible to succeed with the head lettuce because of the rot. Fumigation of house, the use of fresh or steamed earth each year and the careful regulation of temperature and water supply, seem to be the measures most favorable to prevention. A low night temperature, less than 50 degrees F. is very desirable, while too high a temperature will usually result in disease. Ventilation is all essential during the day. It is desirable also to gather and burn rotted leaves and plants.

MAPLE.

Anthracnose:[85]—This disease attacks young Norway maples (See N. Y. Sta. Report '95) and has been also identified on the young shoots of sugar maples in Ohio. The new leaves were reported destroyed by the fungus. Applications of Bordeaux mixture should check this disease.

Rhytisma and Leaf-spot:—The leaves of cultivated maples are often disfigured by dark colored incrustations following the line of the veins. These incrustations are almost black and are caused by a fungus.[86] The trouble is usually not serious, but if prevalent it would seem advisable to gather and burn all leaves attacked by it. The leaf-spot fungus[87] often causes small spots, or dead areas, in the leaves. This may sometimes prove so serious as to call for applications of fungicides.

MILLET.

Leaf-spot:—Leaves of millet, dying from small, light-colored spots, were recently examined. These spots are due to a fungus[88] and the dying may at times be enough to shorten the yield of forage.

Smut:—The seeds of millet are often attacked by the millet smut fungus[89] which transforms them into black masses of smut spores, much after the manner of stinking smut in wheat. This is liable to injure the feeding value of the millet, although it is not likely that the smut will injure stock when millet is fed in usual quantities. All smutted grain, of course, is ineffective and useless and the smutted seed when again sown will produce a smutted crop. The smut is prevented by the same hot water seed treatment as that applied to prevent oat smut. In experiments conducted by the Botanist of this Station this treatment was successful.

MUSKMELON.

Downy Mildew of muskmelon is caused by the same Plasmopara fungus as the downy mildew of cucumbers. As we have the fungus

[85] *Gloeosporium apocryptum* E. & E.
[86] *Rhytisma acerinum* (Pers.) Fr.
[87] *Phyllosticta acericola* (Cke. & Ell.)
[88] *Piricularia grisea* (Cke.) Sacc.
[89] *Ustilago Crameri* Kornicke.

in Ohio it does not appear until towards the middle of August, but is then very destructive, sweeping rapidly over the melon fields and leaving only devastation behind. In its attacks the spots of the muskmelon leaves are somewhat different in shape and usually of a darker color than in the case of the cucumber. One with experience can readily distinguish by the use of an ordinary hand-glass. He will then see on the under side of the leaf the violet spores and spore-bearing threads of the mildew fungus. The melons which are unripened upon the vines when attacked by mildew are practically worthless and for this reason large losses are usually incurred. The treatment is by Bordeaux mixture, as for cucumbers.

Muskmelon Leaf Blight is a disease more or less peculiar to the muskmelon, although the fungus[90] which causes it has also been found upon cucumber leaves. The leaf blight causes rather large dead areas in the leaves which are usually distinguished from those of downy mildew by their larger size and the tendency of the central portion to break out. The prevention of muskmelon leaf blight is by no means an easy matter, requiring of itself great thoroughness and carefulness in the application of the Bordeaux mixture and also requiring that the downy mildew shall be watched during the same period. For this reason earlier sprayings, if made before August 1st, should be repeated at fortnightly intervals, while those after August 1st should be at weekly or ten-day intervals. Melon growers have succeeded by following these lines, while others who were less thorough were less successful, or failed entirely. The treatment is recommended with confidence. (Bulletins 73 and 105).

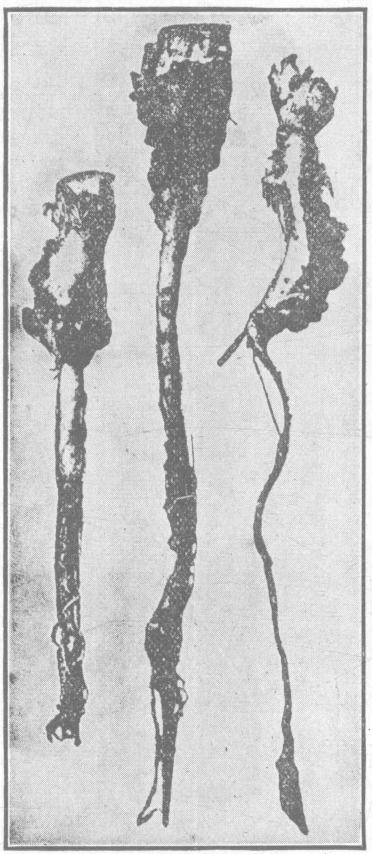
Figure 30. Alternaria Leaf Blight of muskmelon leaf.

Muskmelon Wilt is the same in general character as that described for the cucumber. Not only the bacterial wilt disease but the wilt due to fusarium has developed upon muskmelons in this state. The symptoms are the same as for cucumbers, namely; sudden wilting as from lack of water, followed by dying. The preventive treatment is the same as before recommended.

[90] *Alternaria sp.*

MUSTARD.

Club-root:—Mustard plants generally are attacked by the club-root fungus[91] when this is present in the soil. For this reason the weeds of several species may be infested upon lands that have never been brought under cultivation. Due attention should be given to mustard plants in new lands when designed for cabbage.



Figuere 31. Roots of shepherd's purse attackd by Club-Root.

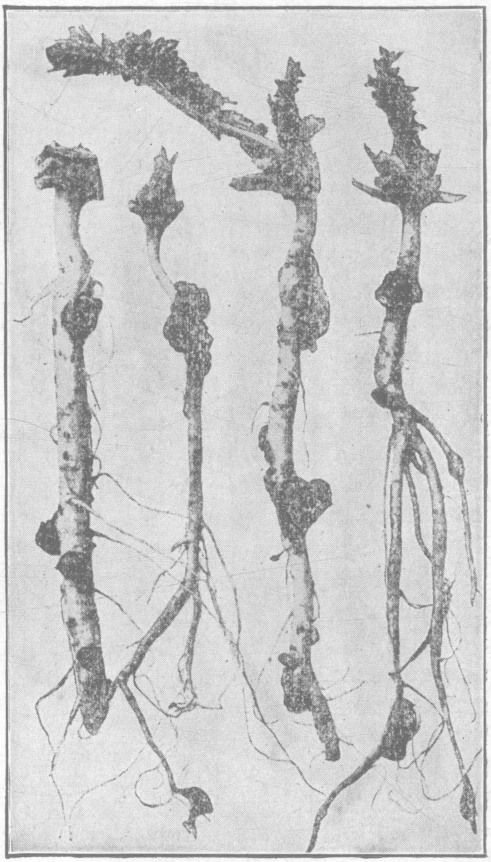


Figure 32. Roots of hedge mustard with Club-Root (Both after Halsted, Bul. 98, N. J. Exp. Station).

OATS.

Bacterial Disease of oats has been at times destructive. It causes dying of the lower leaves and more or less yellowing of the young plants. (See Journal Mycology Vol. VI, page 72). It has been observed on oats at this Station but as yet no effective remedy has been discovered.

[91] *Plasmodiophora Brassicae* Wor.

Rust:—In addition to the two species of rust found upon wheat, and to be given under that grain, there is a rust common upon oats,[92] usually prevalent during the rainy harvest weather and more or less at all times. No remedy is as yet at hand.

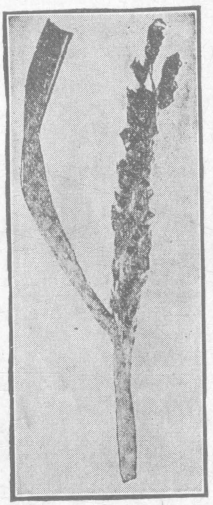


Figure 33. Panicle of oats destroyed by Loose Smut.

Smut:—The smut of oats takes on two forms, the loose smut[93] and the hidden smut.[94] The first, which is the more common, converts the entire head, including glumes, into a sooty mass of smut spores, while in the hidden smut the enclosing glumes remain about the smutted grain. No other essential difference has been found between them. Both are caused by spores from smutted seed, or seed from smutted grain, and both are successfully prevented by seed treatment with hot water or formalin as per scheme given elsewhere. (See Calendar and also Bulletins 64 and 97). An increase of yield beyond smut prevention has usually followed seed treatment. This alone pays for the cost of treatment and the saving from smut loss is clear profit.

OAT-GRASS.

Smut:—There has been at the Station a smut on tall oat-grass[95] which closely resembles loose smut of oats but is, in fact a separate species of smut whose mycelium survives in the rootstocks of the oat-grass.[96] The smut is thus continued in the same plants from year to year. It is not clear whether the smut would be transmitted in new seed, but there is some danger, at least.

ONION.

Blight:—Blight of onions during mid-season, when the weather is warm and dry, is rather a common occurrence. This was especially noticeable during 1898 and 1899. While often attributable to insects, species of fungi, especially molds,[97] were abundant in the seasons named. It may be possible to check these molds by spraying.

Downy Mildew[98] is likely to occur upon onions, although it has not been seen in Ohio by the writer. The treatment would be as for downy mildews of other plants.

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[92] *Puccinia coronata* Corda.

[93] *Ustilago Avenae* Jens.

[94] *Ustilago Avenae laevis* (Jens.) Kell & Swing.

[95] *Arrhenatherum elatius* L.

[96] *Ustilago perennans* Rostrup.

[97] *Macrosporium Sarcinula parasiticum* (B.) Thüm—*M. Porri* Ell.

[98] *Peronospora Schleideniana* D'By.

Onion Smut, on the other hand, is prevalent to a considerable extent in Ohio, and is one of the most destructive of the smut fungi known to pathologists. This onion smut,[99] unlike the other smuts with which we have to do, propagates itself almost indefinitely in the soil when this once becomes infested. Whenever a new crop of onions is grown from seed in this infested soil the smut attacks the young seedling onions, in whole or in part, and a very considerable loss results therefrom. If however onion sets are put in such soil, or seedling onions that have been started under glass in healthy soil are transplanted to smut infested soil, the smut fungus cannot attack them. The explanation seems to be that the smut threads are only able to penetrate the leaves of the young, tender seedlings. This onion smut is now known to occur in fields at Berea and near Chillicothe. At the latter place it has seriously embarrassed some of the growers of onions for sets; for this work transplanting is, of course, out of the question. In Connecticut Experiment Station Report for 1889, it is stated that flowers of sulphur have been used to sow with the seed in infested soil, and this remedy has given but slightly inferior results to any other yet tried at this Station. Forty percent formaldehyde, known commercially also as formalin, has given better results than sulfur in 1900.

Figure 34. Smutted and sound onion seedlings. (From a photograph by P. A. Hinman.

PEA.

Blight, Leaf-spot, Sun Scald:—Young peas are frequently blighted and have the leaves spotted by fungi referable to the genera Ascochyta and Septoria.[100] These troubles have been described by Dr. Halsted (N. J. Exp. Sta. Rept. 1893). As yet they have not proved very troublesome in Ohio.

Powdery Mildew:[101]—The mildew fungus often attacks the pea and at times entirely destroys its fruitfulness. It may be known by the whitish coating produced upon the leaves and by the dark, pin-head spots of the fungus observed to be situated in these white

[99] *Urocystis Cepulae* Frost.

[100] *Ascochyta Pisi* Lib. & *Septoria Pisi* West.

[101] *Erysiphe communis* Wallr.

coverings. The same fungus likewise attacks the bean. For either plant spraying with Bordeaux mixture, as per directions in calendar, will be found beneficial. The first application should be made promptly.

PEACH.

Crown Gall:—This is a very contagious disease of the peach and of other fruits, notably raspberry, blackberry and pear. Sometimes it produces excrescences and enlargements upon the root and stem of the affected plant. More commonly the galls are found upon the stem just below the surface of the earth. These vary in size and in location, even occurring upon the small roots, and less frequently upon the stem at some distance above the ground. In some recent experiments (Bulletin 104) it was found that the gall trouble became communicated from diseased raspberries to peach trees set in the plantation. In some instances the losses from crown gall have been large and there is, in my judgment, no other disease common to several of our fruit trees that is so threatening in its ravages. The peach trees attacked in most cases perish without producing fruit. This applies when the trees are affected at nursery age—the usual condition. Purchasers cannot afford to set such diseased trees nor nurserymen to ship them. As yet the only treatment we can recommend is to dig out and burn the diseased trees, and to avoid planting affected stock. This, with other diseases of the peach, has been treated in Bulletins 92 and 104.

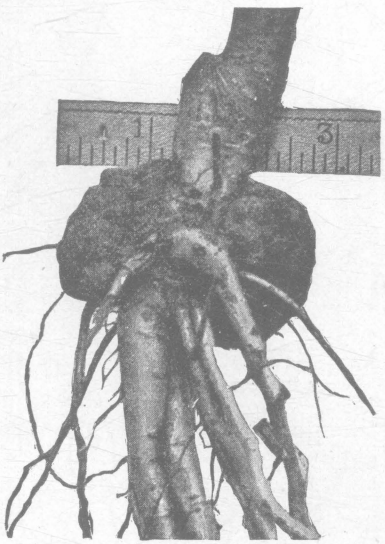

Figure 35. Root of nursery peach tree attacked by Crown Gall.

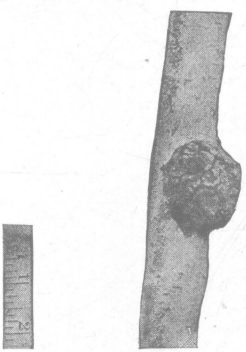

Figure 36. Crown Gall attacking stem of peach tree.

June Drop is often named by peach growers as a specific trouble. It consists in the dropping of the young peaches during the month of June, though dropping sometimes comes earlier. The cause appears to be physiological and need not to be feared where trees have been prevented from overbearing, or protected from the effects of drought by thorough cultivation the previous season.

Little Peach is a disease much discussed in Michigan and quite serious in the fact that the peaches on diseased trees never come to proper maturity or develop marketable character. Dr. Smith has

found that the root hairs on many such trees are not healthy and thus it appears that some specific trouble is located there.

Leaf-curl:[102]—The leaf-curl fungus is at times one of the serious pests of the peach grower. However, destructive leaf-curl does not occur every year. The curl fungus survives as mycelium in the buds from year to year. It is therefore present each season, though possibly in varying amount. We have found in Ohio that serious leaf-curl comes when cool weather, with frequent rains, prevails during April, May and June. It is to the April weather that the most serious results seem attributable. With low temperature and frequent rains during the early half of this month we may safely predict an outbreak of leaf-curl. (Bulletin 92). During such weather the fungus develops rapidly and the new leaves are affected as they are protruded from the bud. In a modified sense the same takes place during May and in a still more limited way during June. Successful prevention of leaf-curl is secured by thorough early treatment with Bordeaux mixture. Indeed, it appears that a spraying at any time shortly before the blossoms open is several times more effective than any application afterward. It appears that more effective results are secured by spraying two weeks before blossoming than immediately before the blossoms open. In any event an application made just before the blossoms open is much more effective than at any later date. Whale-oil soap has also proved effective applied at this time, though not safe at much earlier dates. It is more expensive than Bordeaux mixture. (See Bulletins 92 and 104).

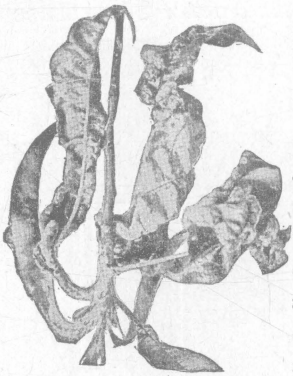

Figure 37 Effects of Leaf-Curl on peach. (After Atkinson. Bul. 73 Cornell Expt. Sta., reduced).

Leaf-Spots of the peach may be due to a variety of causes and in no cases studied have they proved destructive. These are illustrated and briefly discussed in Bulletin 92.

Pustular Spot of the peach is a disease referable to a minute fungus[103] which is apparently spread by spores that alight upon the upper surface of the fruit, flourish there and produce minute, light-brown spots, often surrounded by an angry, red border. The red border is conspicuous in earlier varieties and is sometimes elevated and pustular in appearance. This fungus greatly disfigures the fruit and is very easily prevented. Three applications of Bordeaux mixture have reduced the amount of pustular spot to less than one percent; whereas unsprayed trees gave more than 16 percent of spotted fruit, much of which was seriously damaged. (Bulletin 92).

[102] *Exoascus deformans* B.

[103] *Helminthosporium carpophilum* Lév.

Rot, or Brown Rot:—The brown rot fungus[104] is among the most destructive of the fungi on the peach, yielding place only at times to leaf-curl. Unlike leaf-curl the brown rot prevails during warm, showery weather, and with such a weather period is likely to occur at any time of the year. In April, if the mummy peaches are permitted to remain on the trees from the preceding year, the fungus may affect the twigs through the blossoms and thus cause serious twig blight. It is a matter of common remark that the branches upon which rotted peaches are found often perish from the effects of the rot fungus. No one variety seems more susceptible to rot than others, although some sorts are more liable to ripen during rainy weather and then rot worse. The control of rot demands: First, careful removal and destruction of all mummy rotted peaches; second, thorough spraying of the trees before blossoming, as for leaf-curl; Third, subsequent spray treatment as per calendar, may be profitable under certain conditions.

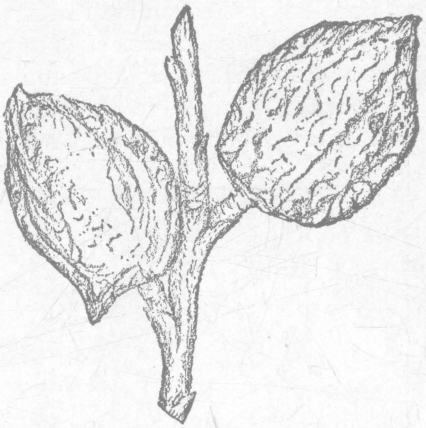

Figure 38. Rotted and dried, or "mummy" peaches on tree in spring.

Root Rot:—In some instances, notably at Gypsum, Ohio, where peach trees were planted in a dense, clay soil, the roots often decay, apparently from the attacks of some fungus. Trees thus attacked usually perish soon. Whether the trouble is primarily due to the fungus or to the location in which the trees are grown has not been determined.

Scab:—The scab fungus[105] is prevalent during rainy seasons particularly upon susceptible varieties, such as the Morris's White, Salway, Heath, etc. It causes dark spots upon the fruit. As brought out in experiments published in an earlier bulletin (No. 92) spraying with Bordeaux mixture may greatly reduce the proportion of affected peaches, and if continued may check the scab. As was stated for leaf-curl, an early application is essential.

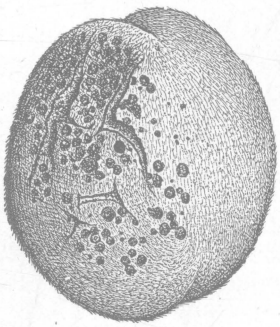

Figure 39. Peach attacked by scab. (After Smith, Farmers' Bul. 17, U. S. Dept. Agric.

Twig Disease with Gum-Flow sometimes referred to as gummosis is, like crown gall, a trouble of recent development in Ohio. In it we find small, diseased or dead spots on the twigs, usually near the buds, and there is

[104] *Monilia fructigena* Pers.

[105] *Cladosporium carpophilum* Thüm.

ordinarily a copious flow of gum from these spots. The trunk may likewise be affected, though less commonly, unless the bark beetle has punctured the trunk. In large orchards it would be wise to dig out and burn the earlier cases of gum-flow, and in general, treatment of the trees with fungicides should prove useful.

Winter Injury:—In our climate the severe freezing of winter often injures the trunk and branches of peach trees. The common

Figure 40. Peach Yellows: winter buds of diseased tree unfolding in autumn. (After Smith, Farmers' Bul. 17, U. S. Dept. Agric.)

killing back of new growth by freezing is a familiar phenomenon. The less common killing of the trunk on one side, usually the west or southwest, is less known. Many instances have been studied. Wherever there has been late growth of the trees, followed by severe winter cold, such injury may be expected. Late cultivation is therefore to be avoided. Winter injury to fruit trees may be attributed to the drying out of the trees and it is worth while to consider whether by mulching, or soil conditions, the tree may not be made to have at

command an abundant supply of available moisture when the upper soil is frozen hard. Much injury to peach trees from freezing occurred during February, 1899. In the larger proportion of these cases there was more water in the soil, or about the trees, than in the less injured localities. More exposed situations also gave more injured trees.

Yellows:—Peach yellows is a serious, contagious disease of this fruit in most portions of Ohio. Only in certain seasons may we find yellowish color as a marked symptom of affected trees. The true symptoms of yellows are:—1. Premature ripening of the fruit which is highly colored, often purplish spotted, and has the flesh marbled with red. 2. The premature growth of winter buds, resulting in excessive branching on new shoots, and the development of slender, wiry-branched twigs. 3. Resting buds, or adventitious buds are formed on the trunk and branches; these grow into sickly shoots with pale, narrowed leaves, and usually become much branched, with tips like veritable brooms. Aside from these specific evidences of yellows which serve to distinguish yellow color from true yellows disease, there are others less easily described but none the less useful to the practical observer. This disease may be recognized late in season by the late, adventitious growth. The sources of disease are diseased trees or affected nursery stock, more often the former. The remedy is to remove and to burn the yellows trees, root and branch, on the spot where found. Dragging diseased branches may spread yellows and all such trees are a menace. To leave an open hole over winter and replant the next year is a safe practice. (See Bulletins 73 and 92 for fuller discussion).

PEAR.

Pear Blight or **Fire Blight** is one of the most serious drawbacks of pear growing. The symptoms of dead twigs and branches are well known. In substance our knowledge of pear blight is about this:—It is due to a bacterium[106] which, in the old cases of blight winters over in the blighted parts. With April and May showers there is some exudation of watery substance from these parts, which is visited by insects and by them transmitted to the opening blossoms. The microbe there breeds in the nectar of the blossom and in that manner attacks the branches; once within the tissues the microbe may spread indefinitely. Some varieties of pears are more susceptible, apparently, than others, which simply means that in them the microbes spread more rapidly. There is not a single blight-free variety of pear in our region. The remedy consists in cutting off and burning the blighted parts each autumn, extending the work to the crab-apple, apple, and indeed to every variety of pome fruit which is attacked by this bacterium. (Bulletin 79, Yearbook U. S. Dept. of Agric. 1895).

[106] *Baccillus amylovorus* (Burr.)

Crown Gall:—The crown gall attacks the pear both at the crown and upon tips of roots. It is less rapid in its destructive effects here than upon the peach, though but slightly less serious. Enlargements may be readily detected and they are usually of denser, more woody growth than upon the peach. The same remedies apply here as with that fruit.

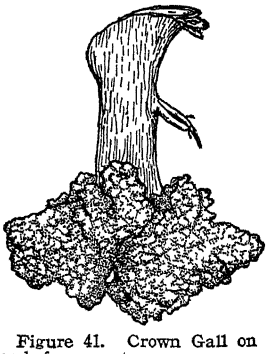

Figure 41. Crown Gall on end of pear root.

Leaf Blight of the pear is produced by the leaf blight fungus[107] which causes spotting and dying of the leaves, also cracking of fruit. The diseased leaves show a dense, dark colored coating on the under side. This disease is readily and successfully prevented by the use of Bordeaux mixture.

Leaf-spot of pear is another fungous disease which may flourish despite the use of Bordeaux mixture, as generally applied. This fungus[108] appears not to yield to the standard fungicides. It produces small, circular dead spots in the leaves; the spots in later summer may drop out, leaving holes. It is quite prevalent, but as yet no specific recommendations can be made for it.

Pear Scab is a fungous disease allied to Apple Scab; the pear scab fungus[109] being very similar in development to that of apple scab. This fungus was very abundant in 1898. It may cause spotting of the leaves or splitting of the fruit of the pear but is not readily distinguished from the other troubles, save by the use of the microscope. It is prevented by the use of Bordeaux mixture.

Sun Scald or Trunk Blight often shows itself in dead patches upon the trunks of pear trees. It is frequently a serious trouble, and is thought at present to be referable to the localized attacks of the pear blight bacterium. The removal of rough bark and the maintenance of smooth condition of the trunks of trees, together with the possible application of a whitewash of strong Bordeaux mixture, are suggested for this trouble.

PLUM.

Black-Knot:—This is the same disease as that described under black-knot of cherry. It is more frequent upon the Damson than upon the other European plums, but requires only the removal and burning of the knots each year before March, in order to grow plums successfully and without serious injury from this disease.

Crown Gall is occasionally found on the plum and is similar to that appearing upon peach and pear.

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[107] *Entomosporium maculatum* Lév.

[108] *Septoria piricola* Sacc.

[109] *Fusicladium pirinum* (Lib.) Fukl.

Plum Rot is by all odds the most serious disease with which Ohio plum growers have to deal, outranking by far black-knot, shot-hole fungus and all the other ills plums are heir to. It is the same in character as the rot of other stone fruits. As with the peach, the rot fungus[110] lives in the winter in the mummy rotted plums of the year before and possibly, to a limited extent, in affected branches. The first step in successful control of rot is the removal and burning of these old plums. The next step is to spray thoroughly, before the buds open, and to continue the spraying and picking the rotted plums as circumstances demand. Likewise, control the curculio. For details of treatment see calendar. No halfway measures will yield satisfactory results in dealing with plum rot.

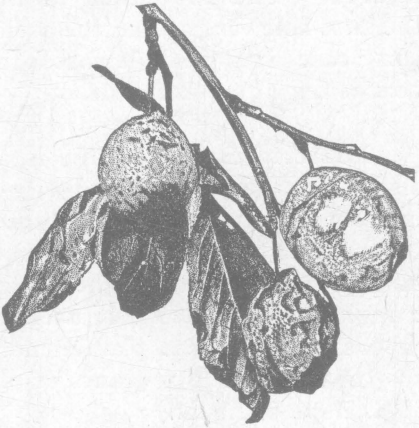

Figure 42. A cluster of plums destroyed by Brown Rot.

Shot-Hole Fungus is at times a very destructive disease of the plum. It is due to the same fungus[111] which attacks the cherry, although in this case even more serious injury is liable to result than with cherry trees. Where trees are defoliated by shot-hole fungus the fruit is of small value and the trees put forth new foliage and blossoms, thus leaving immature wood and a sappy condition for trouble in winter. Under such circumstances the secondary losses may be enormous. This fungus is readily prevented by spraying with standard Bordeaux mixture, the first application being made when the leaves are half grown, and two more at intervals of about three weeks.

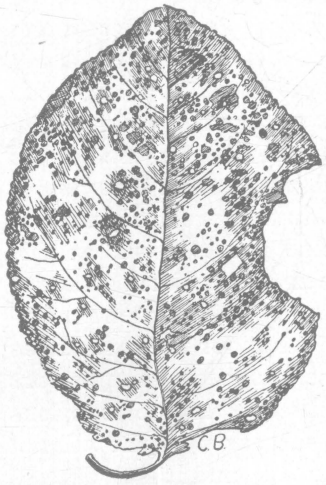

Figure 41. Plum leaf attacked by Shot-Hole fungus or Leaf-spot.

Winter Injury or so-called **Sun Scald:** —In 1896-97, following neglected cases of shot-hole fungus which defoliated the trees in the fall of '96, some plum orchards of Ottawa county were almost entirely destroyed by the severe winter freezing. The sappy trees were not in condition to withstand the severe cold,—15 degrees

[110] *Monilia fructigena* Pers.

[111] *Cylindrosporium Padi* Karst.

Young trees were killed to the snow line while older trees had the sides of the trunk, commonly that facing to the southwest, severely injured. The prevention of this trouble lies in the prevention of the shot-hole fungus and the avoidance of the conditions named. In some cases it is possible that protection of the trunk by straw or boards might be profitable.

POTATO.

Bacterial Blight:—This is a serious disease of the potato; it also attacks the tomato and egg-plant. It has been referred to a microbe.[112] The parts of the stem attacked die off suddenly and the tubers from the affected plants have a dark discoloration of the tissues in a distinct ring at a slight distance from the exterior of the potato. Fungicides are practically useless for this disease. Such diseased tubers should not be planted nor should potatoes follow a diseased crop of tomatoes, egg-plants or potatoes. (Div. Veg. Path. B. No. 12, U. S. Dept. of Agric.)

Early Blight of potato is a premature spotting and dying of the potato leaves, due to the work of a parasitic fungus.[113] The occurrence of the early blight, however, is liable to be influenced by the general vigor and other conditions of the plant; yet there is no just basis for denying, in the light of our present knowledge, the parasitic nature of this disease. Jones has made cultures of the fungus and produced the disease by inoculation (Vermont. Exp. Sta. Buls. 24 and 28; Rept. 1892) and has secured most admirable results by the use of fungicides. This successful spraying in itself is in the nature of proof of parasitic character. In the potato work at this Station it has been the uniform practice to spray thoroughly with Bordeaux mixture, adding arsenites for the insects, as required, and it has been many years since we have suffered any serious loss from early blight. However, the spraying for early blight will not prevent the bacterial disease above described, and it is doubtless the confusion of these two diseases that has led to such differences of opinion among potato growers as to the efficiency of spraying with Bordeaux mixture for early blight. Our recommendation is still that contained in the spray calendar, namely: to spray with Bordeaux mixture.

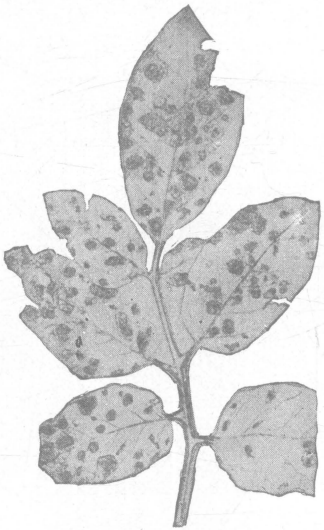

Figure 44. Early blight on potato leaf. (After Jones).

[112] *Bacillus solancearum* Smith. [113] *Alternaria Solani* (E. & M.) Jones & Grant.

Late Blight or **Rot** of the potato is a fungous disease referable to a particular mildew fungus.[114] This mildew spots the leaves, producing a downy, felt-like covering in spots on the under side of the leaves of infested plants. It is said to prevail during wet seasons. While I have seen specimens that attest its actual presence in Ohio, I have never met with a case during six years of careful field work. Spraying is a successful remedy against it when found.

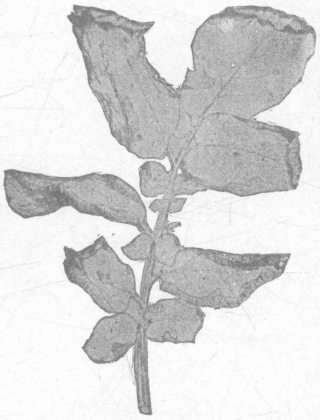

Figure 45. Tip-Burn of potato leaf. This is a simple drying up of the leaf borders. (After Jones.)

Potato Scab is a well known parasitic disease of the potato tuber that needs no extended description. Whether due to fungi or bacteria, or both, the practical prevention of potato scab consists in destroying the parasites on the seed potatoes and then in planting them in soil free from those organisms. The organisms in question will usually be found in soil on which potatoes were grown the previous year, or in that freshly manured. The materials used by this Station in treating for scab are two; namely, solution of corrosive sublimate and solution of formalin, as per strengths given in spray calendar. It is ineffective to treat the seed and then plant on scab-infested land.

A **Stem Rot** or **Dry Rot** especially on the Enormous variety is referred to a species of *Fusarium*. This disease is new with us. Remedies are left to the future.

PUMPKIN.

Downy Mildew and **Wilt** attack pumpkins after the manner described under muskmelon and cucumber. The remedies are the same as there stated.

QUINCE.

Fire Blight:—Fire blight is found in the quince as in the pear and is explained in the same manner. It requires the same treatment.

Leaf-spot and **Rot:**—Despite the ease with which it is grown, no other orchard fruit is left so much to the ravages of fungi as is the quince. Most conspicuous of these is the fungus[115] which attacks the leaves and fruit. In the fruits the spots are first small, circular, dark in color but subsequently will extend and more or less involve and ruin the whole. This fungus, as well as another, namely the leaf blight fungus of the pear, sometimes found upon the quince, is thoroughly held in check, or prevented, by applications of Bordeaux mixture.

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[114] *Phytophthora infestans* D'By.

[115] *Sphaeropsis malorum* Berk.

RASPBERRY.

Anthracnose:[116]—The anthracnose fungus is a frequent bane to the raspberry grower. It attacks the young canes and so spots and injures them, as well as the foliage, that when the time arrives for ripening the fruit the plants are unable to do this and the crop is largely lost. The Horticulturist of this Station has always succeeded in holding this disease in check by the use of the methods of spraying recommended in the calendar for anthracnose. Care, however, must be used in the application of the spray to reach the stems of the young canes and to keep the fungicide from the leaves of bearing canes where it will do injury.

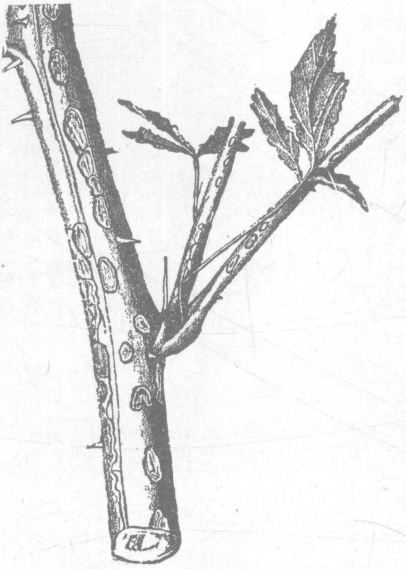

Figure 46. Raspberry stem attacked by Anthracnose.

Crown Gall is at present one of the most destructive diseases attacking raspberries. In some well marked cases upon the variety known as Thompson's Prolific (Bulletin 79) eelworms have been suggested as the possible cause of the gall production, but whatever the cause of the galls attacking that variety we have found them transmitted to the peach in the same soil and we have found that practically all of the varieties of raspberries are attacked by a similar trouble producing like excrescences. These galls result in the destruction of the bearing canes, and where the raspberries are planted in orchards the disease, it would seem, may extend to the orchard trees as well. Late investigations of Tuomey (Arizona, B. 33) show that a slime mold fungus is the cause of crown gall on the almond. Prompt removal and burning of all affected canes is the only method of treatment. Indeed it has been demonstrated from the very beginning that a healthy raspberry plantation cannot be secured by the selection of apparently healthy plants from diseased areas. Nothing remains but to secure plants from the healthy plantations.

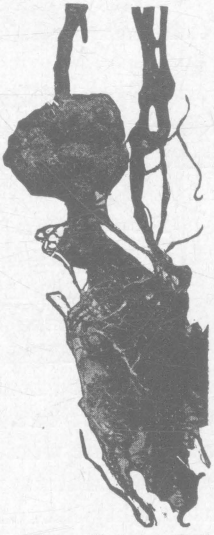

Figure 47. Crown Gall on raspberry plants. These also occur on the roots.

Bacterial Blight of raspberries has been described by this Station; it has not recently proved serious. (Bulletin 79).

[116] *Colletotrichum venetum* (Speg.) Hals.

Leaf-spot and Rust:—The leaf-spot fungus, already described for blackberries and dewberries, upon which it is more commonly found, was prevalent last season upon raspberries. The only remedy for rust is the removal and destruction of all clumps either wholly or partially infected. The leaf-spot fungus[117] will yield to spraying with Bordeaux mixture.

ROSE.

Nematodes:—Among the most serious of the rose diseases is that caused by the eelworms or nematodes which attack the roots. As with cucumbers, these parasitic worms induce the growth of small, bead-like galls upon the roots of the rose. The leaves dry up from the margins, the plants generally turning yellow and breaking down as the outcome of this interference with the proper work of the roots. This subject of nematodes is discussed at length in Bulletin 73. No successful remedy has been found for plants once attacked. The method of prevention consists, as in the case of cucumbers already cited, in the proper steaming and treatment of the soil designed for use in the rose benches.

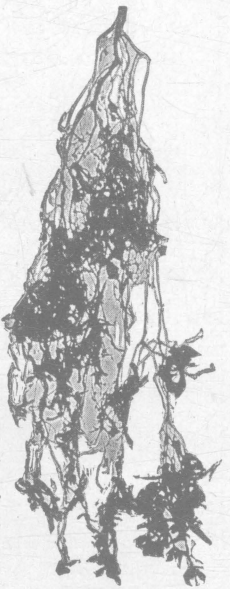

Figure 48. Branch of rose root with Nematode Galls.

Rose Mildew is attributable to the fungus[118] which is commonly prevalent in rose houses; it is also found occasionally out of doors. This mildew is, for forcing houses, largely diagnostic; indicating, when prevalent, uneven temperatures. Proper attention to the matter of heat is the best preventive. Sulphur is often sprinkled upon plants and is frequently used upon steam pipes, but it is not clear that the influence is very great.

Rose Leaf Blotch[119] often causes dark spotting of the leaves. The frost-like, branching growth over the leaf surface is often very pretty in design though injurious in effect. If the rose house is too moist, or if other conditions be slightly unfavorable, the fungus seems to flourish all the better. It may be checked by the use of Bordeaux mixture or by dilute copper sulfate solution, as recommended for cucumbers in the greenhouse (One pound to fifty gallons).

Rose Rust:—Two rusts[120] occur upon the rose in a wild state, but have not been met on cultivated roses here. In New Jersey

[117] *Septoria Rubi* West. *Caeoma nitens* Schw.

[118] *Erysiphe pannosa* Lév.

[119] *Actinonema* (Lib.) Fr.

[120] *Phragmidium speciosum* Fr. and *Ph. subcorticum* (Schw.) Wint.

(Report Exp. Sta. 1892) Dr. Halsted has met with rose anthracnose[121] and we have found two or three cases during the winter of 1890-1900.

RYE.

Ergot[122]—This fungus has been known for a long time. It transforms the grain, after the manner of stinking smut of wheat. It is not extensively prevalent with us.

Rust:—Rye is attacked by about the same rusts as wheat.[123] See wheat.

Smut[124] is also found in rye, but the fungus in this case is peculiar to this plant. Hot water treatment for 5 minutes at 127 degrees F. has been recommended for this smut.

SORGHUM.

Bacterial Blight of sorghum is somewhat similar in its general appearance to the bacterial blight of corn already described. It has been described in the Kansas Exp. Station Report for 1888.

Sorghum Grain Smut[125] attacks the seed of the sorghum plant. Hot water treatment may doubtless be adapted to prevent this smut. Head smut[126] is also known.

SPINACH.

Mildew:—The downy mildew fungus[127] is already known upon lamb's quarters and may appear upon the cultivated spinach of the same order. It shows discolored or dead spots in the leaves with felted, downy covering underneath. Methods of prevention here would be as for cucumbers, except that applications could scarcely be made after the plants are nearly developed.

Anthracnose, Scab and White Smut of spinach have not yet to my knowledge been discovered in Ohio.

SQUASH.

The squash is attacked by the diseases already described under cucumbers, namely, anthracnose. downy mildew and wilt. The remedies are likewise the same.

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[121] *Gloeosporium Rosae* Hals.
[122] *Claviceps purpurea* Tul.
[123] *Puccinia graminis* Pers. and *P. rubigo-vera* (DC.)
[124] *Urocystis occulta* (Wall.) Radh.
[125] *Cyntractia Sorghi-vulgaris* (Tull.) Clinton.
[126] *Ustilgo Reiliana* Kühn.
[127] *Peronospora offusa* (Lév.) Rabh.

STRAWBERRY.

Strawberry Leaf-spot,[128] **or Rust,** so-called, is a well known spotting of the older strawberry leaves. The leaf-spot fungus matures in the old leaves.

Other fungi, of different species, may also be found on the strawberry, but the same statement holds true for the important sorts. While spraying may be useful, the practice of burning over strawberry beds to destroy old leaves and the fungi is based upon right principles. It is also commonly successful.

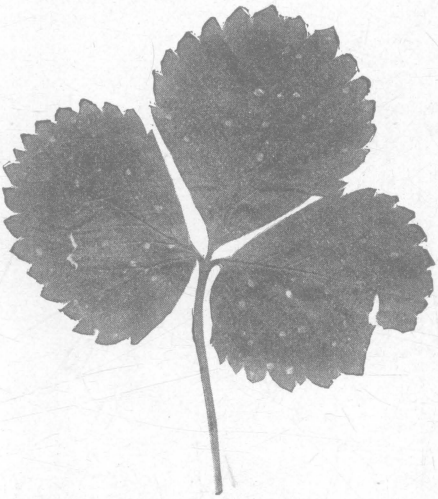

Figure 49. Strawberry Leaf spot. The light centers have dark borders.

SUGAR BEET.

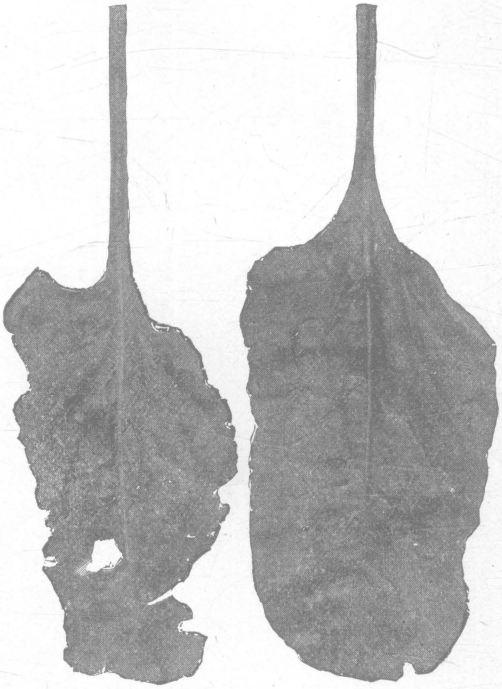

Figure 50. Leaf-spot trouble on sugar beet.

Leaf-spot:—The sugar beet, which is beginning to be extensively cultivated with us, has been injured by the leaf-spot fungus[129] and by other diseases. The leaf-spot produces small, dead areas in the beet leaves, followed at times by dying of all the leaves. For this fungus Bordeaux mixture may be applied with confidence, at intervals of three weeks. The first application should be made when the plants are about 5 or 6 inches high.

Beet Scab affects the roots of the beet as the scab does potato tubers. It is thought to be due to the some organisms. It may be avoided largely by avoiding

[128] *Sphaerella Fragariae* (Tul.) Sacc.
[129] *Cercospora beticola* Sacc.

the conditions for scab already mentioned under potato scab. Rotation of sugar beets will probably be required to escape these and other diseases.

SWEET POTATO.

Bin or **Soft Rot** is encountered by the sweet potato growers. The fungus[130] producing it may be present in the plant bed and apparent as dark spots or rotted tips on the plants at setting. All such plants ought to be discarded if avoidance of disease is sought. Some experiments were made at Marietta in 1897, to prevent or reduce this rot, but without positive advantage in the keeping qualities. A dope, or mixture of 6 parts earth to one part flowers of sulfur, was dropped in handfuls and the plants set through the mixture thus bringing it about the roots of the plant very nicely. Smoother potatoes were obtained and these separated more readily from adherent earth, but no better keeping resulted for that year. The potatoes were harvested, however, during a wet period and conditions were less favorable than is often the case.

Soil Rot[131] is a serious disease of sweet potatoes for which the above described treatment has proved successful in New Jersey. (N. J. Exp. Sta. Bul. 126).

Stem Rot[132] attacking the stems and roots has appeared in Ohio sweet potato fields, apparently introduced by affected seed. Such seed should be avoided. Rotation may also be necessary.

White Mold or **White Rot**[133] is common upon the Man-of-the-earth and the morning-glory (*Convolvulus hederacea*) in the sweet potato districts, but apparently is not frequent upon sweet potato foliage.

SYCAMORE.

Anthracnose[134] is often destructive on the foliage of this tree, and while it should be amenable to treatment with fungicides, it has been usually neglected.

TOMATO.

Anthracnose[135] occasionally causes small, depressed spots in tomatoes. It may be checked by the use of Bordeaux mixture.

Bacterial Blight of the tomato, egg-plant and potato has already been mentioned. It was destructive at Mt. Carmel, near Cincinnati, in 1896 (B. 73). It has since been locally destructive. It causes sudden blighting and decaying of the stems and branches attacked.

[130] *Rhizopus nigricans* Ehrh.
[131] *Acrocytis Batatas* Ell. & Hals.
[132] *Nectria Ipomoeae* Hals.
[133] *Cystopus Ipomoea-panduranae* (Schw.) Farl.
[134] *Gloesporium nerviseguem* (Fckl.) Sacc.
[135] *Gloesporium phomoides* Sacc.

Spraying has as yet proved useless for this blight. Preventive measures recommended include fighting insects, early removal of diseased vines, choice of fresh land not previously in potatoes or egg-plants, and tomato seed from healthy sources. To date, this disease has been less destructive than the leaf-spot.

Tomato Leaf-spot or **Leaf Blight** is an outdoor trouble, as are the two former. The leaf-spot fungus[136] appears to be gradually traveling westward from the Atlantic coast, where it first appeared several years ago. During 1898 it was locally disastrous over the whole of Ohio, and again during 1900. It may be successfully prevented by about three thorough sprayings with Bordeaux mixture, though some difficulty attaches to the treatment of unstaked tomato plants in the field. (Bulletins 73, 89, 105).

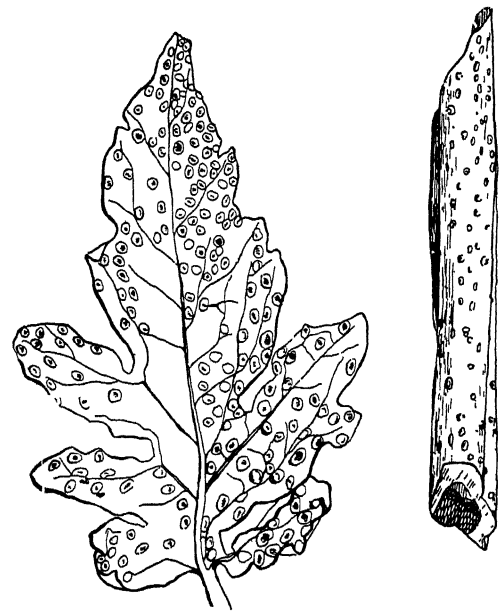

Figure 51. Tomato leaflet and stem attacked by Leaf-spot.

Nematodes may be very injurious to tomatoes grown under glass. They cause, as on cucumber plants attacked, gall-like enlargements on the small roots of the tomato. Previous soil treatment to destroy the nematodes is the remedy in this instance, as in the other. It will usually occur that tomato plants are less susceptible to injury by nematodes than are cucumbers and melons.

Leaf Mold[137] is a common trouble on tomato forcing-houses near the close of the season. It produces spots in the leaves, while beneath they are covered by the grayish-brown mold fungus. The fungicides heretofore recommended for use in the greenhouse are available for the tomato leaf mold.

Point Rot of green tomatoes, especially in the forcing-house, is often the most serious trouble with which the tomato grower under glass has to contend. It was stated in Bulletin 73 that this trouble was observed to be most destructive in cases of scant water supply in the soil. This observation was again confirmed by the Horticultural

[136] *Septoria Lycopersici* Speg.

[137] *Cladosporium* (?) *fulvum* Cooke.

Department of the Station during the season of 1899. The trouble was checked by abundant and careful watering, even when it had been very bad, and was again produced by withholding water and allowing the plants to dry out. The cause appears to be entirely physiological, and while other physiological causes than the one just stated may be conceived as competent to produce point rot, none other appears so likely or so common. The remedy lies, of course, in the avoidance of conditions from which the rot may result.

TURNIP.

Club-root:—This fungus organism[138] infests the roots of many cultivated mustard plants, including the turnip, radish, rutabaga, etc. The treatment is the same as stated under cabbage.

VERBENA.

Mildew:—Cultivated verbenas are attacked by the mildew[139] which is so common on the wild vervains. It is to be treated as other powdery mildews, by spraying with fungicides.

VIOLET.

Leaf-spot and **Leaf Blight**[140] are sometimes prevalent, and with downy mildew of violet should yield to spraying with fungicides.

Nematodes of violets are, on the other hand, not amenable to spray treatment. The parasite in the case is the same as named under cucumber nematodes, likewise its effects. Soil treatment will also be effective in prevention here.

WATERMELON.

With the possible exception of the wilt disease and the leaf-spots the diseases of the watermelon are the same as those which attack cucumbers and muskmelons. They include anthracnose, downy mildew and leaf blight. The leaf-spot of the watermelon is referred to a disinct fungus[141] though its ravages are, possiby, not general. (See Bulletins 73, 89, 105). In the treatment of watermelon vines it is advisable to use the more dilute Bordeaux mixture, Bordeaux II, of the calendar.

WHEAT.

Rust:—While essentially the same, to the ordinary vision, wheat rust is produced by two rust fungi,[142] of which only the last named may pass the winter in the wheat plant. Both have the red and the black (dark) stages and are very damaging under, to them, favorable conditions of weather and grain. In Europe, Australia and California

[138] *Plasmodiophora Brassicae* Wor.

[139] *Erysiphe Cichoracearum* DC.

[140] *Phyllosticta Violae* Desm. and *Cercospora Violae* Sacc.

[141] *Cercospora Citrullina* Cke.

[142] *Puccinia graminis* Pers. & P. *rubigo-vera* (DC).

wheat growers hope to select rust-proof varieties of wheat, and this is, as yet, the only promise of rust prevention on wheat. (Bulletin 97).

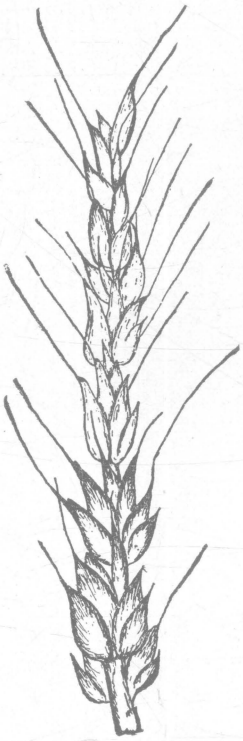

Figure 52. Wheat spike with Scab; the upper portion has been destroyed by the pink fungus.

Figure 53. Heavy spike of bearded wheat destroyed by Loose Smut.

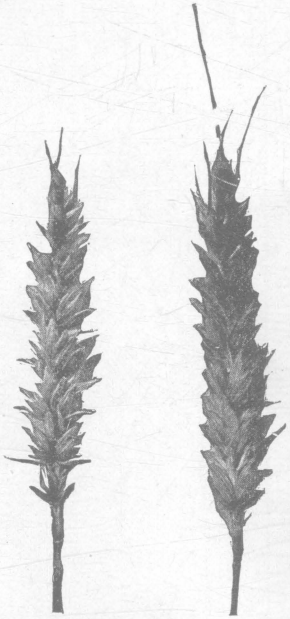

Figure 54. Smutted and sound spikes of Poole wheat; in one at left the kernels have been destroyed by Stinking Smut and spikelets are spread abruptly.

Wheat Scab:—This is also due to a particular fungus,[143] which attacks the rachis and the glumes of certain wheat heads, producing on these heads a reddish or pink incrustation, and destroying that part of the spike. This fungus survives the winter in its perithecial form upon wheat heads, straw, etc. It is liable to be worse when a crop of diseased wheat has preceded the wheat. No remedy beyond avoidance has been proposed. (B. 97).

Loose Smut:—This is a smut fungus[144] which converts grain and glooms into a sooty mass of spores. These heads of loose smut are most obvious at the blossoming of the wheat. The disease is worse on certain varieties of wheat. It may be prevented by the modified hot water treatment as per calendar.

[143] *Fusarium roseum* Lk.

[144] *Ustilago Tritici* Jensen.

Stinking Smut of wheat is caused by a still more destructive smut fungus,[145] which converts the kernels of wheat into dirty, stinking masses of spores. These, if abundant, ruin the flour and render wheat valueless for human food. At times 40 percent of the wheat is thus destroyed and the losses from it are often very large. Recent investigations have established that this smut is caused by the smut spores sown with the seed grain. If the smutty seed wheat is treated with a fungicide, such as bluestone, hot water, formalin, etc., which will destroy these spores without injury to the grain and the treated seed is then prevented from subsequent infection, dried and sown, a clean crop may be grown from smutted seed. For details of treatment see calendar and Bulletin 97, which treats of the diseases of wheat.

[145] *Tilletia foetens* B. & C.

SEED AND SOIL TREATMENT AND SPRAY CALENDAR*

FOR INSECT PESTS AND PLANT DISEASES

PREPARED BY W. J. GREEN, A. D. SELBY AND F. M. WEBSTER

This Bulletin is designed to cover the needs of farmers and horticulturists. It was first prepared as a spray calendar at the request of the Ohio State Horticultural Society. Insecticides and Fungicides may often be combined, and, where Bordeaux mixture is used for fungous diseases, this practice is recommended. Spraying young orchards with Bordeaux mixture from time of planting, and of stocks in nursery row, is strongly recommended to preserve healthy conditions.

FUNGICIDES

1. Bordeaux Mixture I

Copper sulfate (blue vitriol) 4 pounds.
Quicklime (not air slaked) 4 pounds.
Water, to make 50 gallons.

Dissolve the copper sulfate in about two gallons of hot water, contained in a wooden vessel, by stirring, or even better, by suspending the sulfate contained in a cheese cloth sack, in a large bucketful of cold water. With the cold water and cheese cloth bag, a longer time is required. Pour the sulfate solution into the barrel or tank used for spraying, and fill one-third to one-half full of water. Slake the lime by addition of a small quantity of water, and when slaked cover freely with water and stir. Pour the milk of lime thus made into the copper sulphate, straining it through a brass wire strainer of about 30 meshes to the inch. Pour more water over the remaining lime, stir and pour into the other; repeat this operation until all the lime but stone lumps or sand is taken up in the milk of lime. Now add water to make 50 gallons in the tank. After thorough agitation the mixture is ready to apply. The mixture must be made fresh before using, and any left over for a time, should be thrown out or fresh lime added.

2. Bordeaux Mixture II

Copper sulfate, 2 pounds.
Quicklime, 2 pounds.
Water, to make 50 gallons.

For use on such trees as have foliage injured by Bordeaux I.

STOCK SOLUTION

A solution of copper sulfate containing say one pound of sulfate to the gallon of water may be made up and permitted to stand indefinitely in a covered barrel if no lime is added. Such a solution is known as a stock solution, and two or four gallons of this stock solution, according to the strength desired, are taken for each 50 gallons of mixture to be made. For extensive spraying, a long trough or box of uniform width may be used in which to slake and keep the lime. The quicklime is weighed out according to the amount needed immediately, placed in the trough and slaked with a small quantity of water. The whole is evenly spread and covered as a putty, with water to exclude the air. This putty may be removed in calculated portions, placed in a tub and treated like the freshly slaked lime. By means of stock solution of copper sulfate and the lime in putty state, much valuable time is saved in filling the barrels used in spraying. [By suspending the blue vitriol in cheese cloth bag just below surface of water, 40 pounds will dissolve readily over night in 40 gallons of water.]

3. Ammoniacal Solution of Copper Carbonate

Copper carbonate, 6 ounces.
Ammonia, about 3 pints.
Water, 50 gallons.

Dissolve the copper carbonate in the ammonia and add the water.

Caution: Use no more ammonia than is required to dissolve the copper carbonate. Ammonia is variable in strength, and the amount required must be tested in practice.

To make copper carbonate: Dissolve 10 pounds copper sulfate (blue vitriol) in 10 gallons of water, also 12 pounds carbonate of soda in same quantity of water. When cool, mix the two solutions slowly, stirring well. Allow the mixture to stand twelve hours and settle, after which pour off the liquid. Add the same quantity of water as before, stir and allow to stand the same length of time. Repeat the operation again, after which drain and dry the blue powder, which is copper carbonate.

*Reprint of Bulletin No. 102.

4. Copper Sulfate Solution

Copper sulfate, 4 pounds.
Water, to make 50 gallons.

Dissolve the sulfate as directed in Bordeaux I.
Caution: This solution will injure foliage. It can be used only before the buds open.

5. Potassium Sulfid Solution

Potassium sulfid (liver of sulfur) 1 ounce.
Water, 3 to 4 gallons.

This solution will not remain unchanged. The potassium sulfid must be kept in a well stoppered bottle.

6. Formalin

For oats and wheat, 1 pound (1 pint) formalin to 50 gallons water
For potatoes, ½ pint formalin to 15 gallons of water.

7. Corrosive Sublimate

Corrosive sublimate, 2 ounces.
Water, 15½ gallons.
Label Poison; use for potato scab and disinfection.

To hasten solution, have druggist pulverize the sublimate.

INSECTICIDES

8. Kerosene Emulsion

Dissolve one-half pound hard soap in one gallon of water (preferably soft water) and while still boiling hot, remove from the fire and add two gallons of kerosene. Stir the mixture violently by driving it through a force pump back into the vessel, until it becomes a creamy mass that will not separate. This requires usually from five to ten minutes. The emulsion is then ready to be diluted with water and applied. For the common scale insects and hard bodied insects, like the chinch bug, use 1 part emulsion to 8 or 10 parts water. For soft bodied insects (plant lice, etc.) use 1 part emulsion to 15 or 20 parts water.

Kerosene emulsion kills by *contact* and therefore the application should be very thorough. It may be used against a great many different pests, but is especially valuable for destroying those with sucking mouth-parts, for they cannot be killed with arsenical poisons.

9. Paris Green

In combination with Bordeaux mixture, Paris green may be used at the rate of 1 pound to 175 to 200 gallons.

When Bordeaux mixture is unnecessary, the Paris green may be used at the same rate, but two or three pounds of freshly slaked lime must be added to prevent burning of the foliage. Keep the mixture well stirred so that the poison will be distributed evenly.

In cases where successive sprayings are necessary, it is important to consider the accumulation of poison and use a slightly weaker mixture, unless sufficient rain has fallen to wash off the poison thoroughly.

10. London Purple

If desirable, London purple may be substituted for Paris green, but it has the disadvantage of being somewhat variable in composition and contains more soluble acid. For that reason it must be used somewhat weaker, or else an abundance of lime provided, so as to prevent burning of foliage. It has the advantage of not settling as readily as Paris green.

11. White Hellebore

Hellebore is often employed in cases where arsenical poisons would be objectionable. Use one ounce to three gallons of water.

12. Pyrethrum

Pyrethrum is usually applied as a powder, with a bellows, but may be used as a spray at the rate of one ounce to two gallons of water.

13. Whale Oil Soap Solution

Use from one to two pounds of the soap to one gallon of water. Be sure that the soap is thoroughly dissolved, and then apply in form of spray. 1 pound to gallon of water if used for peach leaf curl only.

14. Arsenite of Soda

Dissolve two pounds of commercial white arsenic and four pounds of carbonate of soda (washing soda) in two gallons of water and use one and one-half pints to a barrel of Bordeaux Mixture (50 gallons).

The easiest way to make the solution is to put both the white arsenic and carbonate of soda in a gallon of boiling water and keep boiling about fifteen minutes, or until a clear liquid is formed, and then dilute to two gallons.

Caution:—Label this solution Poison as it is colorless.

SEED AND SOIL TREATMENT

Seed or plant	For what treated	Treatment	Method of treatment
Barley	Smuts	Modified hot water	Soak seed enclosed in sacks 4 hours in cold water, let stand wet 4 hours more and dip 5 minutes in hot water at 130 degrees F., or three degrees lower than for other hot water treatments.
Bean	Anthracnose	(See spray calendar)	
	Weevil	Bisulfid of carbon	Submit to fumes for 24 hours in air-tight vessel.
Begonia	Nematodes	Heat soil with steam	Disinfect soil to be used by heating with steam as described under cucumbers.
Cabbage and Cauliflower	Club root	Quicklime on soil	Apply stone lime (quicklime) before planting, at rate of 80 bushels per acre and work into soil with tools
	Maggot	Bisulfid of carbon	Make hole in soil near roots, pour in about a teaspoonful of bisulfid of carbon and fill hole with soil.
Cucumber	Nematodes in hot-house.	Heat soil with steam	Heat earth before using in a special box for 3 hours with 60 lbs. of steam, or 4 hours with 40 lbs. See Bulletin 73.
Oats	Loose smut	Immerse seed in hot water. Soak seed in Potas. sulfid. Sprinkle seed with formalin or copper sulfate	Immerse seed contained in open vessel for 10 minutes in hot water at 132-3 degrees F., for 7 minutes at 136 degrees F., or for 5 minutes at 140-2 degrees F., spread at once to dry. (2.) Soak seed in ¾ per cent. solution potassium sulfid for 24 hours with stirring, then dry. (3.) Sprinkle a pile of seed to saturate with formalin or copper sulfate, one gal. to bu. After 2 to 3 hours spread to dry. For latter use lime in drying. See Bulletin 97.
	Insects in stored grain	See wheat	
Onion	Smut	Plant other crop. Use sets or transplanted seedlings. Sprinkle seed before covering, with formalin, as for oats	The soil once infected by spores of onion smut cannot easily be freed from them. Long planting in other crops or use of sets or transplants yields favorable results.
Potato	Scab	Soak uncut seed in corrosive sublimate or formalin	Soak seed for one hour in corrosive sublimate, or for 2 hours in formalin, then dry and plant on scab free soil.

SEED AND SOIL TREATMENT

Seed or plant	For what treated	Treatment	Method of treatment
Roses	Nematodes in hot-house	Heat soil with steam	Heat soil with steam as described above; thoroughly disintregated soil from sod one year or more old is less dangerous. Lime water stimulates affected plants, but is not a remedy.
Sweet Potato	Bin rot	Use flowers of sulfur in soil	Make dope 1 part flowers of sulfur and 6 parts earth:—Drop handful and set plant through it.
	Soil rot	Use flowers of sulfur	(Same as above).
Tomato	Nematodes in hot-house	Heat soil with steam	As for roses and cucumbers above.
	Point rot in hot-house	Mulch of subwater	A supply of available water appears to be unfavorable to point rot of green tomatoes.
Turnip	Club root	Quicklime in soil	As for cabbage and cauliflower. Avoid succession of mustard crops.
Violet	Nematodes in hot-house	Heat soil by steam	The time for prevention is by soil treatment beforehand, as for cucumbers above.
Wheat	Loose smut	Modified hot water	Soak seed 4 hours in cold water, let stand 4 hours more in wet sacks, immerse 5 minutes in water at 133 degrees F. and dry.
	Stinking smut	Hot water, copper sulfate or formalin.	Dip skimmed seed for 10 minutes in hot water at 133 degrees F. and dry on disinfected surface, or immerse 10 minutes in blue stone, dry with air slaked lime by shoveling. Use 2 lbs. blue stone to 10 gals. water. Grain may be sprinkled with copper sulfate or formalin, as for oats. See Bulletin 97.
	Insects in stored grain	Bisulfid of carbon	Place one pound of bisulfid of carbon for each 2,000 lbs. of grain in bins. Cover surface to hold the fumes which will spread through the mass, killing all insect life. Use in tight bins or buildings and do not use near fire of any description.

SPRAY CALENDAR

What to spray	For what to spray	With what to spray	When to spray	
			First spraying	Second spraying
Apple	Bitter rot	Ammoniacal cop. carb.	With first appearance of rot	Two weeks after first
	Scab	Bordeaux mixture I	As buds are swelling	Just before blossoms open
	Sooty fungus	Bordeaux I	After blossoms drop	Two weeks later
	Bud moth	Arsenites in Bordeaux I	With opening of buds	
	Canker worm	Arsenites alone, 9 or 10	With first young worms	In 1 week if worms remain
	Codlin moth	Arsenites in Bordeaux I	As soon as blossoms fall	7 to 10 days later
	San Jose scale	Whale oil soap solution	As soon as leaves drop in fall	Just before fol. starts in spring
	Woolly aphis	Kerosene emulsion	When trees are not in full leaf	In fall
Aster	Blister beetle	Whale oil soap	When beetles appear	
Asparagus	Asparagus Beetle	Lime or Pyrethrum	Early spring	
Bean	Anthracnose	Bordeaux I	Soak seed 1 to 2 hrs. in am. cop. car. five times strength of 3	Bord. on 2 to 3 in. plants
Beet	Leaf spot	Bordeaux I	When plants are 5-6 in. high	Two weeks after first
Cabbage and Cauliflower	Cabbage worm	Pyrethrum	With first appearance of worms	Whenever worms observed
	Club root	(See soil treatment.)		
Carnation	Leaf or calyx mould	Bordeaux I or ½ of 4	Upon appearance of fungus	Two weeks later
	Leaf spot	Bordeaux I or ½ of 4	Upon appearance of fungus	Two weeks later
Celery	Leaf spot or leaf blight	Bordeaux I	On young seedlings	Repeat on seedlings
Cherry Stocks	Leaf spot	Bordeaux II	When leaves are half grown	Two weeks later
Cherry	Leaf spot	Bordeaux II	When leaves are unfolding	Two weeks later
	Rot (?)	Bordeaux I and II	Before blossoming I	After blossoms drop II, on fruit
	Aphis	Whale oil soap	On first appearance of aphis	
	Cherry slug	Arsenites in Bord. II	When slugs appear	Repeat if slugs remain
	Curculio	Arsenites in Bord. I and II	Before blossoming in I	As blossoms dry up in II
	San Jose scale	Whale oil soap solution	In fall as with the apple	As with the apple
Cinerarias	Mildew	Bordeaux I or ¼ of 4	When mildew appears	Two weeks later
Chrysanthemum	Leaf spot	Bordeaux II or ¼ of 4	July 1	Two weeks later
Cucumber	Anthracnose	Bordeaux I	When plants begin to vine	Two weeks later
	Downy mildew	Bordeaux I	July 25 to August 1	Eight to ten days later
	Spot of fruit	Bordeaux I	After first blossoms	Ten days later
Currant	Leaf spot	Bordeaux I	As leaves are unfolding	Two weeks later
	Plant bug	Kerosene emulsion	May	Early June if necessary
	San Jose scale	Whale oil soap solution	As with the apple	In spring as with apple
	Worm	White hellebore	When worms first appear	In 3 or 4 days repeat
Gooseberry	Leaf spot	Bordeaux I	As currants with leaf spot	As currants with leaf spot
	Mildew	Bordeaax I or 5	Before leaves open I	After blossoming I
	Worm	White hellebore	As for currants	
Grape	Anthracnose	Bordeaux I	Just before buds open	Just before blossoming
	Berry moth	Arsenites with Bordeaux I		After fruit has set
	Downy and powdery mildew	Bordeaux I	Just before blossoming	After fruit has set
	Rot	Bordeaux I and 3	Just before buds open Bord. I	Just before blossoming I
	Leaf hopper	Kerosene emulsion	Before young can fly	
Horse Chestnut	Leaf spot or blight	Bordeaux I	When leaves are half grown	Two weeks later
Muskmelon	Anthracnose	Bordeaux I and II	In seed bed or when plants begin to vine Bordeaux II	Two weeks later Bord. I
	Downy mildew	Bordeaux I	July 25 to Aug. 1	Eight to ten days later
	Leaf blight	Bordeaux I	When plants begin to vine	Three weeks later

SPRAY CALENDAR—Continued

For what to spray	When to spray		Remarks and cautions
	Third spraying	Fourth spraying	
Bitter rot	Two weeks later	Not required if Bord. precedes	These follow Bord. for scab; danger on fair skinned apples
Scab	Just after blossoms drop	7 to 10 days later	
Sooty fungus	These coincide with 3d and 4th for scab		
Bud moth			
Canker worm	Same as second		
Codlin moth	These coincide with 3d and 4th for scab. Paris green alone on light apples		White skinned apples are injured by spraying after 3d
San Jose scale			Two lbs. soap dissolved in 1 gallon water
Woolly aphis			Don't use emul. when trees are in full leaf
Blister beetle			Use 1 lb. soap to 6 gals. water
Asparagus Beetle			Do not use arsenites, except in late summer
Anthracnose	Bordeaux 10 days later	After blossoms	Repeat if needed
Leaf spot	Two weeks later		
Cabbage worm			1 oz. to 3 gallons water, or dust 1 to 10 of flour
Club root			
Leaf or calyx mould	Two weeks later	Repeat if needed	Begin early before calyces are ruined
Leaf spot	Two weeks later	Cover foliage well	
Leaf spot or leaf blight	Before or after transplanting	Two weeks later	Keep leaves well covered in plant bed
Leaf spot	Two weeks later	About two weeks later	
Leaf spot	2 or 3 weeks after second		First after blossoming
Rot (?)	Two weeks later II on fruit	Two weeks later II or 3	Use 3 when fruit is large
Aphis			Difficult to reach aphis. Use 1 lb. soap to 6 gals. water
Cherry slug			Air slaked lime may be used
Curculio	One week later in II		Avoid strong solutions
San Jose scale			
Mildew	Repeat if necessary		
Leaf spot	Repeat if necessary		
Anthracnose	Two weeks later	Two weeks later	Repeat as necessary
Downy mildew	Eight to nine days later	Eight days later	Repeat at weekly intervals
Spot of fruit	Two weeks after second	Two weeks after third	Apply to fruit carefully
Leaf spot	Two weeks later	Two or three weeks later	Fourth necessitates washing fruit
Plant bug			
San Jose scale			
Worm	Repeat as second		
Leaf spot	As currants with leaf spot	As currants with leaf spot	This remedy is very successful.
Mildew	Potas. sulfid 2 weeks later		Bord. coats fruit if used for 3d
Worm			
Anthracnose	Just after fruit has set	Ten days later, Bordeaux	Don't spray after fruit is half grown
Berry moth	Ten to fourteen days later		Do not spray with arsenites after July 1st
Downy and powdery mildew	Ten to fourteen days later		Covered by spraying for anthracnose or rot
Rot	Just after fruit has set I	Ten days later, Bordeaux	Follow by two or three sprayings with am. cop. carb.
Leaf hopper			
Leaf spot or blight	Two weeks after 2	Two or three weeks later	
Anthracnose	Two weeks later	Two weeks later	Repeat as necessary, use II very early
Downy mildew	Eight to nine days later	Eight days later	Repeat same
Leaf blight	Three weeks after second	Two weeks after third	

SPRAY CALENDAR—Continued

What to spray	For what to spray	With what to spray	When to spray	
			First spraying	Second spraying
Oats	(See seed treatment).			
Peach	Leaf curl	Bordeaux 1, 4 or 13 and II	In fall or in March, Bordeaux I or 4	As buds are opening 1 or 4. Also 13.
	Pustular spot	Bordeaux II	Just after calyx drops.	Two weeks after first.
	Rot	Bordeaux I and II.	As buds are swelling I	Just after calyx drops II
	Scab	Bordeaux I or 4 and II	As buds are sweling Bord. I or 4	Just after calyx drops Bord. II
	Bud moth	Arsenites in Bordeaux I	With opening of buds.	
	San Jose scale	Whale oil soap solution	As buds are opening in spring.	
Pear Stocks	Leaf spot or blight	Bordeaux I	When leaves are half grown	Two weeks later
Pear	Leaf blight	Bordeaux I and 3.	When leaves are half grown	Two weeks later
	Scab	Bordeaux I	Before blossoms open.	After blossoms drop
	Bud moth	Arsenites in Bord. I	With opening of buds.	
	Canker worm	Arsenites in Bord. I	As with the apple	
	Codlin moth	Arsenites in Bord. I	After blossoms fall	Seven to ten days later.
	San Jose scale	Whale oil soap solution	As soon as leaves drop in fall	Just as fol. starts in spring.
	Slug	Arsenites in Bord. I or dust with slaked lime	When slugs appear.	Repeat if slugs remain.
Pea	Mildew	Bordeaux I	When mildew appears.	Two weeks later
Plum	Rot	Bordeaux I, also 3.	As buds are swelling I	Just after calyx drops I
	Shot-hole fungus	Bordeaux I	When leaves are half grown	Three weeks later
	Curculio	Arsenites in Bord. I	With starting of buds.	Just after calyx drops.
	Aphis	Whale oil soap	On appearance of aphis	
Potato	Early blight	Bordeaux I	When plants are 6 in. high	Two weeks later
	Late blight	Bordeaux I	As for early blight in all	
	Blister beetle	Whale oil soap	When beetles appear.	Repeat if necessary.
	Colorado beetle	Arsenites alone or in Bord I	When beetles or young appear	As for first
	Flea beetle	Bordeaux I	When beetles appear.	Repeat if necessary.
Quince Stock	Leaf spot	Bordeaux I	When leaves are half grown	About two weeks later
Quince	Leaf spot	Bordeaux I	As buds are swelling.	When leaves are half grown.
	Fruit and leaf spot.	Bordeaux I	Before blossoms open.	After blossoms drop
Raspberry and Blackberry	Anthracnose	Bordeaux I and II.	Before leaves open use I	II on young canes 6 in. high
	Leaf spot	Bordeaux I	When leaves are half grown	Two weeks later
	Saw fly	Pyrethrum or hellebore	As for currant worm.	In 3 or 4 days repeat.
Rose	Leaf spot	Bordeaux I or ½ of 4	With first appearance of fungus	Two to three weeks later.
	Slug	Arsenites in Bordeaux II or hellebore	On appearance of slugs	Repeat if needed.
Sugar Beet	Leaf spot	Bordeaux I	With first appearance of spots	Two to three weeks later
	Blister beetle. Flea beetle	Bordeaux I	When beetles appear.	
Tomato	Anthracnose	Bordeaux I	Soon after fruit begins to set	Three weeks later
	Leaf blight	Bordeaux I	Three weeks after transplanting	Three weeks after first
Watermelon	Anthracnose	Bordeaux II	When plants begin to vine	Three weeks after first
	Downy mildew	Bordeaux II	July 25 to August 1	Eight to ten days later
	Leaf blight	Bordeaux II	As disease appears on muskmelon	Repeat as on muskmelons

SPRAY CALENDAR—Concluded

For what to spray	When to spray		Remarks and cautions
	Third spraying	Fourth spraying	
Leaf curl	Just after calyx drops Bord. II	Not required, ditto 3, if others well done	Whale oil soap serves as second.
Pustular spot	Two weeks later		Cover fruit well
Rot	Three to four weeks later II	As fruit begins to color II.	Every 7–10 days repeat. Destroy all mummies. 3 may be used 4th.
Scab	Two weeks later Bord. II.	Two weeks later Bordeaux II.	
Bud moth			Use only half usual amount of poison.
San Jose scale			Two lbs. soap to 1 gal. water. Use only in spring as buds are opening.
Leaf spot or blight	Two weeks later	Two weeks later	5 to 7 sprayings are needed
Leaf blight	Two weeks after second	Bord. may make russet fruit	Use 3 for 3d; not Bord. after 2d.
Scab			Bordeaux after second may injure fruit.
Bud moth Canker worm Codlin moth San Jose scale			Two lbs. soap dissolved in 1 gallon water.
Slug Mildew	Repeat if needed.		
Rot	Three or four weeks later I	As fruit begins to col. use 3	Every 7–10 days repeat 4th; useless to spray for rot, unless mummies are destroyed.
Shot-hole fungus	Three weeks later, if needed		
Curculio	Five days later		Jar and gather stung plums in addition.
Aphis			Use 1 lb. soap to 6 gals. water.
Early blight Late blight Blister beetle Colorado beetle	Two weeks later As first and second.	Two weeks later if needed.	
Flea beetle Leaf spot	Two weeks later	Two weeks later	Perhaps 5th spraying will be needed.
Leaf spot	Two weeks later	Two weeks later	Second should come after blossoms drop.
Fruit and leaf spot	Two weeks after second	Two weeks later.	
Anthracnose	Repeat 2d one week later		Keep spray from leaves on bearing canes.
Leaf spot Saw fly	Two weeks later.		
Leaf spot	Repeat if necessary		Bordeaux shows on plant.
Slug			
Leaf spot	Two to three weeks later	Three weeks later if needed	
Blister beetle Flea beetle			Bordeaux I some danger.
Anthracnose	Three weeks later.		
Leaf blight	Three weeks later	Three weeks later	
Anthracnose	Two weeks later	Three weeks later	
Downy mildew	Eight to nine days later	As for cucumbers	Bordeaux I some danger.
Leaf blight	As on muskmelons		

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